WIDE ROAD AHEAD!

HENRY B. LENT

WIDE ROAD AHEAD!

Building an Automobile

by

HENRY B. LENT

Illustrated by EARLE WINSLOW

$2.00

Wide road ahead—and a shiny new car slides out on to the broad speedway and is off! Only fifty minutes ago this same car was a bare chassis skeleton, but a trip down the marvelous "assembly line" starts it out in full dress—an automobile of the latest model.

In this interesting book Mr. Lent tells boys "what makes the wheels go round" and then takes his young readers directly to Detroit, where they visit a big plant and follow through the whole process from the "idea factory" to the testing grounds. They not only see cars made in record time, but also see them smashed up as parts are tested. Here is an accurate, informational book full of pictures which is interesting and exciting reading for boys over ten.

Boys like derricks, engines, steamboats—and now Mr. Lent chooses another very special interest of theirs—automobiles. He knows just how much story and just how much information young readers like.

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WIDE ROAD AHEAD!

By HENRY B. LENT

DIGGERS AND BUILDERS

Stories of men who run derricks, trucks, steam shovels; who mix cement, build skyscrapers and make roads.

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The story of six days on an ocean liner; exploring it from bridge to engine rooms.

WIDE ROAD AHEAD!

The building of an automobile from the "idea" through to the final tests.

Wide Road Ahead!

The Building of an Automobile

by

Henry B. Lent

Illustrated by

EARLE WINSLOW

New York

THE MACMILLAN COMPANY

1934

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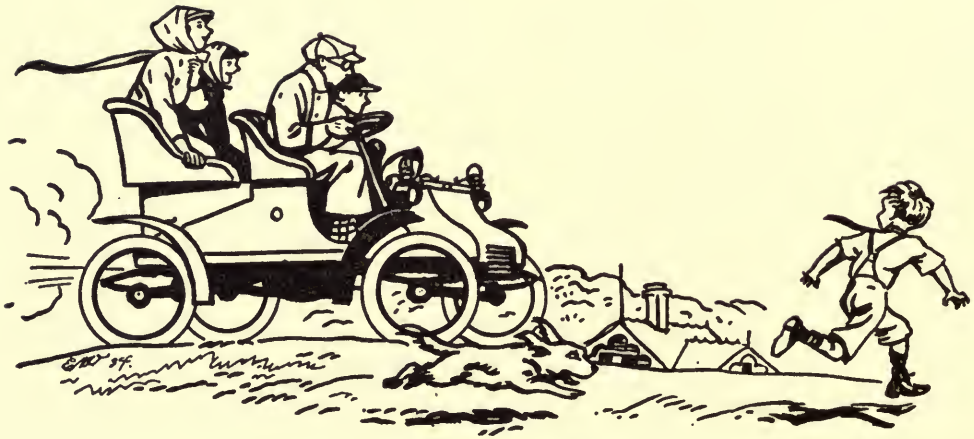

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CONTENTS

CHAPTER		PAGE
I.	"Get Out and Get Under!"	1
II.	What Makes the Wheels Go 'Round	8
III.	Detroit—"The Automobile City"	13
IV.	A Million Dollars for an Idea!	18
	Building the Engine	
V.	The Foundry	29
VI.	The Machine Shop	40
VII.	Ninety Horse-Power in Harness	49
VIII.	The Body Plant	55
IX.	The Assembly Line	67
X.	"Hit the Road!"	84
XI.	"America on Wheels"	95

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ILLUSTRATIONS

	PAGE
An early "gas buggy."	2
A chassis.	9
Cross section of engine.	10
The automobile factory is a city in itself!	15
Drafting a model, actual size.	22
Hydraulic press testing machine.	25
In the Cold Room.	26
The metal flows like fiery water into the bucket.	34
The men pour the hot metal into the molds.	36
Rotary milling machine.	43
The trip-hammer drops on to the crankshaft.	45
Crankshaft balancer.	46
Assembling the engine.	50
The dynamometer test.	52
The giant press stamps out the fenders.	58
The operator of the welding machine throws the switch.	61
The men who spray on the paint wear queer masks.	63

ILLUSTRATIONS

	PAGE
The frames are put on the assembly line upside down.	70
Then the heavy rear axle is lowered into place.	71
Here comes the engine, swinging from a crane.	72
It takes but a minute to fasten on the wheels.	73
The men bolt on the fenders and running boards.	74
Down comes the body on to the chassis.	75
Final inspection.	76
Finished! Fifty minutes to build a car!	77
Plowing through the sand in the desert test.	86
Into the pool of water it goes!	89
Crash! Bang! Over the edge of the hill-top!	93
125 miles an hour on three wheels!	97
The automobile serves the farmer in many ways.	98
Great automobile busses span the country.	99
Every city has its fire engines.	101

I

"GET OUT AND GET UNDER!"

WHEN your grandfather was a boy there were no automobiles. People rode in buggies and carriages drawn by horses. If you have ever been for a buggy ride you know what fun it is.

But a horse and buggy was not a very fast way to travel from one place to another. People were beginning to wish they had a quicker way of getting about.

As time went on, there were two men who thought that perhaps they could make a new kind of carriage that would go along the road without being pulled by a horse. But what could they use instead of old Dobbin to make it go?

They knew that some one had already invented an engine that would run on gasoline. How fine it would be, they thought, to put this gasoline engine in a buggy! Then perhaps the buggy would run along under its own power, faster than a horse could pull it.

So they set to work on their idea. One of the men had been a builder of bicycles and carriages for many years. He knew just how to go about it. In his little shop he and his helper worked for many

months building the parts for their "horseless carriage." People who saw what they were doing laughed at them and said they must be crazy. But the two men paid no attention and just kept on working harder than ever.

Finally their automobile was finished. They rolled it from their workshop. What a funny contraption it was! No one who saw it could understand how a carriage could possibly go without a horse to pull it. It looked like this:

An early "gas buggy."

There was no steering wheel. The driver steered with a long bar at the front of the buggy. The engine was at the back, out of sight under the seat. The strangest thing of all was the socket for the buggy whip! The men who built this automobile thought that it ought to look as much like a buggy as possible. The only thing they were interested in was getting rid of the horse. That was the big problem.

A crowd of curious people stood about the automobile waiting to see what would happen. The driver climbed into the seat. He was not at all sure his "gas buggy" would even start, but he hoped it would. There was only one way to start it. His helper stooped down at the back of the car and twirled the engine crank. What happened then had never been seen before. With a *chug*, *chug*, *chug*, the rickety little buggy began to move. Down the street it went, snorting, in a cloud of dust and smoke. The people cheered. The "gas buggy" really worked!

Soon other men started to build horseless carriages. Some of them would not run at all. Others would run for a little while and then stop. And what a racket these first automobiles made! Bang! Bang! Poppity-pop! . . . like a Fourth of July celebration on wheels.

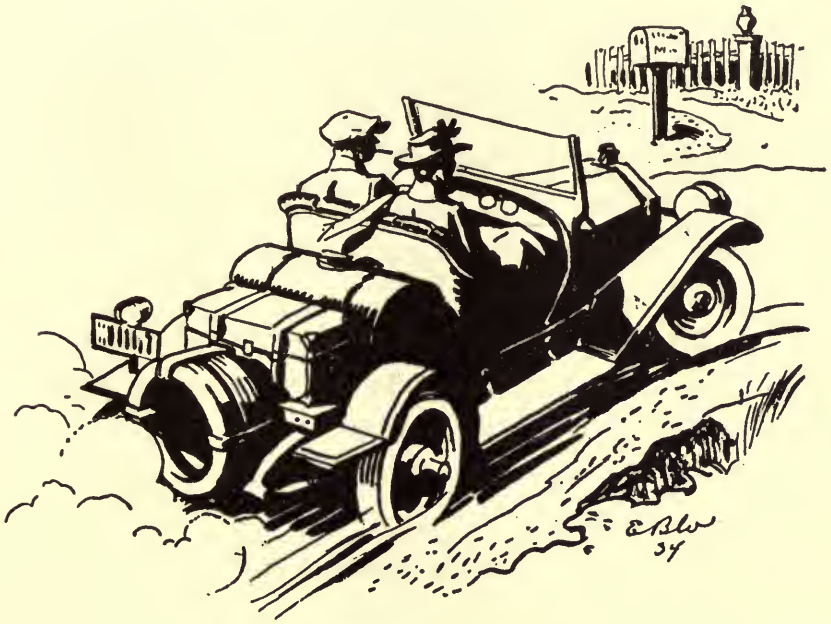
Quite often an automobile would start off in grand style . . . then the engine would sputter and stall. Since there were no garages and no mechanics, repairs had to be made wherever the automobile decided to stop. The owner of the automobile would lie on his back under the car, hammering and tinkering with the engine to make

it start again. When this happened, mischievous boys would sometimes shout: "Get a horse!" Some one even wrote an amusing song about the man who had to "Get out and get under" his automobile.

"Get out and get under!"

At first there were only a very few automobiles. As the years passed, there were more and more. But for quite a long time, an automobile chugging down the street would cause a great deal of excitement. Horses would rear up on their hind legs in fright, and

sometimes run away. People in their houses would throw up their windows and pop their heads out to see the horseless carriage pass by at the reckless speed of eight miles an hour! That seemed very



An automobile of 1915.

fast in those days, especially for a buggy without a horse. People shook their heads and wondered what the world was coming to!

All this, remember, was quite a few years ago. As time went on and more automobiles were built, the models were made better and better. Men learned by their mistakes.

By the time your father was old enough to drive a car, the engine was no longer built under the seat, but was at the front under a hood, as we see it in cars of to-day. Some one had also thought of putting a glass windshield at the front to protect the driver. It was no longer necessary to wear goggles when riding in an automobile. And instead of hard rubber tires, there were rubber tires filled with air . . . *pneumatic* tires. With all these improvements, your father's first car probably looked something like the picture on the last page.

This was a very fine car. Although it still had a crank at the front of the engine, it was not used very often, for by this time some one had invented the self-starter.

It would surprise you to see a car like this running past your house to-day, for it is so different from our cars with their speedometers that read up to 100 miles an hour, their 90-horse-power engines and their streamlined bodies. The wheezy old gas buggy had none of these things.

We remember some of the men who built automobiles in these early days because, even to-day, cars that bear their names are still being built. The Ford is one. Also the Franklin and Packard. Mr. Maxwell's car later became the Chrysler, which is now built in the same enormous factories that make the Dodge, De Soto and Plymouth.

Mr. White, another pioneer automobile builder, is remembered because there are heavy-duty busses and trucks named after him. From the workshop of Mr. Olds came the Oldsmobile, which is

now one of the many fine cars built by General Motors Corporation. Mr. *R. E. O*lds himself is now president of a company that makes a car whose name comes from his three initials. Many of the cars that were well known years ago are no longer made. The Haynes, Stevens-Duryea, Winton, Paige and Overland were all good cars.

Had it not been for the work of these pioneers so many years ago, there might not have been any automobiles for us to ride in to-day. And what a queer old-fashioned world this would be without automobiles!

II

WHAT MAKES THE WHEELS GO 'ROUND

BEFORE many years you will be old enough to get a driver's license. It will be an exciting day, when you can take the car out of the garage and drive off all by yourself!

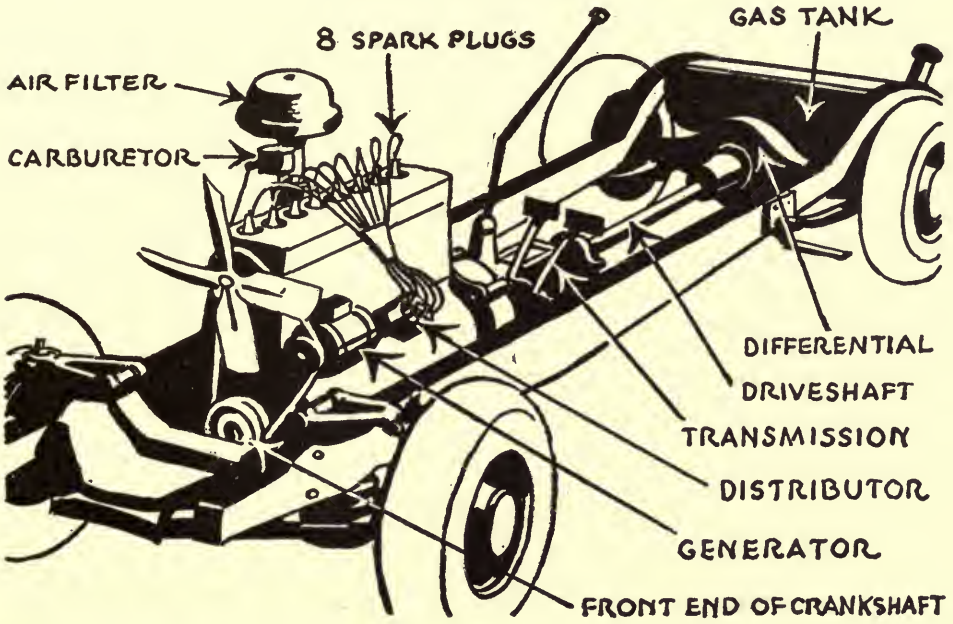
Probably right now you know how to do it. You know all about starting the engine, how to work the clutch and how to shift gears. But every good driver knows *why* certain things are done, as well as *how*.

Many people who know how to drive a car do not know anything about what goes on inside an automobile engine. They know that when they press down the accelerator pedal the car goes faster, but they do not know exactly why. Nor have they ever stopped to wonder how the engine, at the *front* of the car, makes the *rear* wheels go 'round.

You may know some of these things, but just for the fun of it let us go over an automobile together to see what makes it run. Later we are going to visit one of the most interesting places in the world—a factory where automobiles are built. If we take a look at the most important parts of a car before we go, we shall be better able to understand the things we see there.

WHAT MAKES THE WHEELS GO 'ROUND

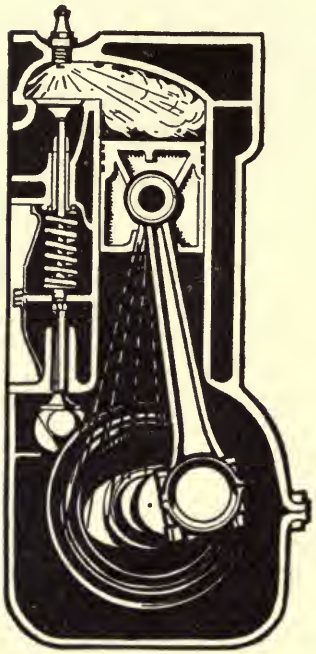
We can see the parts that make a car go more easily if we lift the body right off. This is what we have left:



This is called the *chassis.* An automobile chassis is like a steel frame set on four wheels, with an engine at the front. The radiator, of course, belongs in front of the engine. It has been removed in this picture so we can have a better view of the chassis.

Even without being told, you know that this is an eight-cylinder engine because it has eight *spark plugs*, one for each cylinder. The artist has drawn a picture to show how each cylinder has a *piston*

fitting snugly inside it. Each piston is fastened to the *crankshaft* of the engine by a *connecting rod*. It is quite easy to understand how the engine works. The gasoline comes into the top of the cylinder, above the piston. When the gasoline is exploded by the spark plug, it pushes the piston downward. This turns the crankshaft.



Cross section of engine.

One thing that we must not forget is that the pistons flash up and down inside the cylinders very fast. Even when the engine is running slowly, if we could look inside we would see only a blur of moving parts.

When the engine is running at top speed, the crankshaft turns over 4,000 times a minute, and the eight spark plugs are making 16,000 explosions a minute!

Of course these rapid explosions inside the engine make it very hot. The heat would quickly wear out the engine unless all the moving parts were constantly covered with oil.

But even oil is not enough to keep the engine cool. The automobile engine is built with a double "skin" which helps to get rid of the heat. Between the outer skin and the inner skin is a space for water, which runs in from the radiator. When the water gets hot it returns to the radiator to get cooled again.

There are other parts of the engine that are very important. The *generator*, which is attached to the outside of the engine, is really a small dynamo—smaller of course than the giant turbines in power houses that make electricity to light our homes, but much the same. The generator works whenever the engine is running, making electricity to fire the spark plugs. The extra electricity that is not needed for the spark plugs is carried through a cable to the *storage battery*. Here it is stored for use later, to make the starter work, to light the lights at night, and to blow the horn.

All this is not the way an engineer would explain an automobile engine, but perhaps it is enough to help us understand how it runs. Just remember that the pistons, flashing up and down inside the cylinders, turn the crankshaft round and round. The turning crankshaft gives us the power we need. But how does this power at the front of the car make the rear wheels go 'round?

If you will look at the picture of the chassis on page 9 you will see the *driveshaft*. Just as a ship has a propeller shaft running from its engine to turn the propeller, an automobile has a driveshaft running from its engine to gears in the rear axle to turn the wheels. These gears at the back are called the *differential*.

Usually when we speak of "gears" on a car we mean the *transmission*. The transmission is really the "gear box" of the automobile. To get the car started we shift into "low" gear. This gear gives us lots of power. For more speed we shift into "second" gear. Then when the car is rolling along pretty fast we shift into "high"

gear, which is the gear for speed. To back the car we shift into "reverse," of course.

On the picture of the chassis you can see the two pedals just back of the engine. As you know, the one on the left is the *clutch* pedal. The other is for the brakes. When you press in the clutch pedal, the power from the crankshaft is not being used. When you let the clutch pedal out again the car moves, unless the gears of the transmission are in "neutral."

Now we are going to visit one of the largest automobile factories in the world. We shall make a trip through one building that is half a mile long. We shall see iron and steel heated until they flow like water. We shall walk, like pygmies, around machines that reach thirty feet or more above us—machines that bend steel sheets into shape as if they were paper.

We shall follow the famous assembly line and watch cars being built before our eyes, from the time the bare frame is laid down until a man steps into the finished car, starts the engine and drives it from the building.

III

DETROIT

"The Automobile City"

WHEN you think of automobiles you think of Detroit, the largest city in the state of Michigan. In fact, Detroit is often called "The Automobile City," for it has more automobile factories and builds more cars than any other city in the world.

Many of the best-known cars are built here. Some of them are the Chevrolet, Plymouth, Ford, Dodge, De Soto, Hudson, Cadillac and Chrysler.

Of course there are other cities, too, where automobiles are built. The city of Pontiac, Michigan, is the home of the Pontiac; and nearby, at Flint, is the large Buick factory. The home of the Studebaker is the city of South Bend, in the state of Indiana. The air-cooled Franklin car has always been built at Syracuse, in New York state. But more cars are built in Detroit than in any other city.

It is also interesting to know that every section of the United States has a share in the building of motor cars. Every state sends something that is needed.

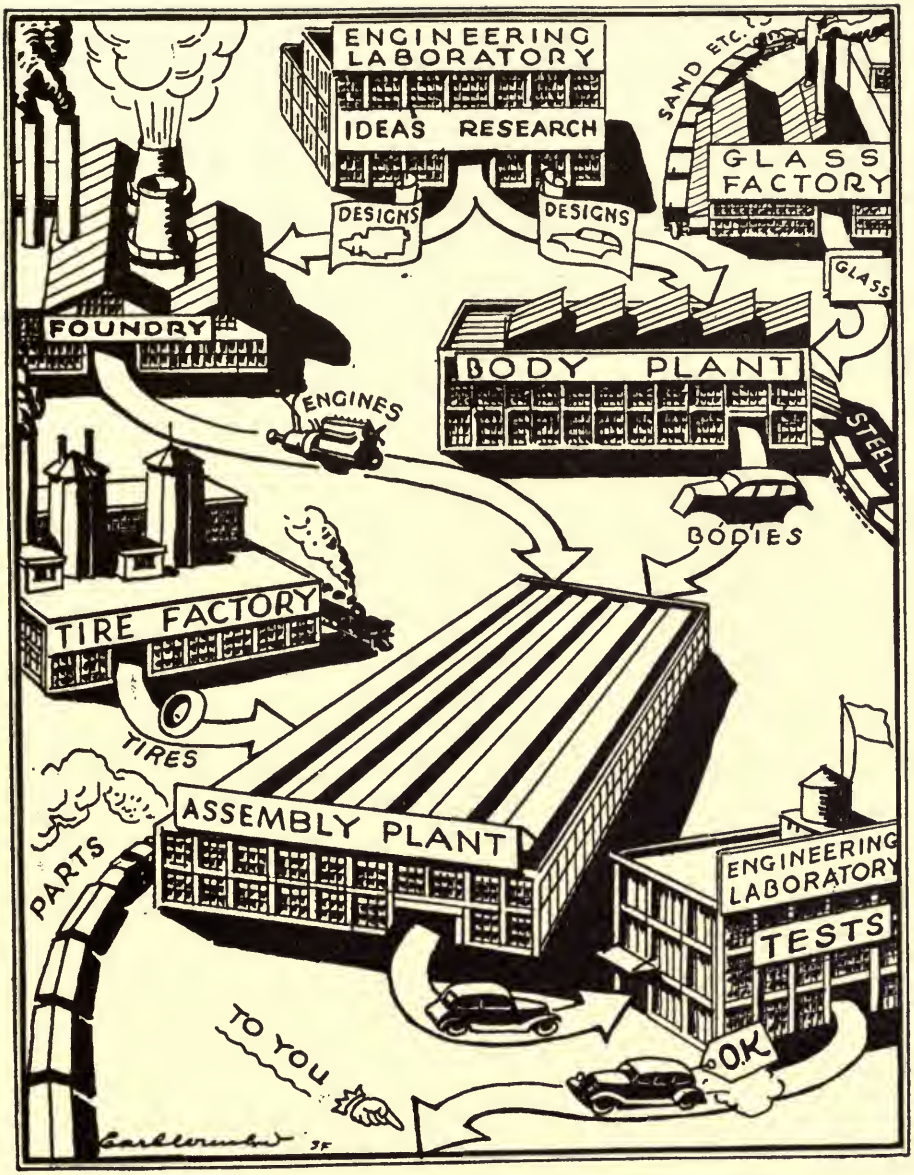
In Akron, Ohio, for example, are the huge tire factories that make millions of automobile tires every year. They make their tires from rubber that is shipped to them from hot countries on the other side of the world, and from cotton that is grown on plantations in the southern part of the United States.

In Pittsburgh, Pennsylvania, are factories that make plate glass for the windows and windshields of automobile bodies.

There are more than one hundred kinds of raw materials needed for the manufacture of automobiles. Some of the most important ones are coal, iron, steel, lumber, copper, tin, aluminum and lead. How many raw materials does your own state send to Detroit? Can you name the states from which come the most coal, steel and lumber?

Other materials come from countries all over the world. Even China and Japan, and countries in Africa and South America, send what they have to offer—all kinds of metal ores, wool, felt, asbestos, and many other things too numerous to mention.

And in order that people may run their cars, large companies have been formed to supply us with gasoline and oil. If you live in Texas, Oklahoma, California, or Pennsylvania, perhaps you have seen how these companies have drilled deep holes down into the earth to get crude oil. Most of it is then shipped by rail to the refineries to be made into gasoline and engine oil, but from some of the oil fields great pipe-lines have been laid down to carry the oil direct to the refinery hundreds of miles away.



The automobile factory is a city in itself!

WIDE ROAD AHEAD!

The automobile industry is the most important industry in the United States. Millions of people all over the country earn their living by building automobiles or doing some work that is made necessary because of the automobile. There are the men who work in the automobile factories, the steel mills, the glass factories, the tire factories. There are the "dealers" who sell the cars, the garage men who fix them when they need repairs, the men at filling stations who sell us gas and oil, and thousands of truck drivers, taxi drivers and bus drivers.

It is interesting to know, too, that if there were no automobiles, the millions of miles of smooth paved highways that have been built to connect every city and town in the United States would probably still be bumpy, dusty dirt roads, just good enough for horses and buggies.

The chart on page 15 is a map of the automobile factory we are going to visit. It shows how the factory is divided, with many separate buildings.

We shall go first to the Engineering Laboratory, for that is where the building of an automobile starts. On this chart you can easily find the Foundry and Machine Shop. This is where the engines are made. Nearby is the Body Plant.

See how everything—engines, bodies, tires, and all the ready-made parts that come by train—finally goes to the Assembly Plant.

This is the longest building of all. Here the many different parts are assembled, or put together.

Perhaps you are wondering why the last building on the chart, as well as the first, is an Engineering Laboratory. There is a very good reason. You might naturally expect that when the finished automobiles are driven from the Assembly Plant, they are ready for the people who wish to buy them. But this is not the case. Before your new car may leave the factory it must have the "O.K." of the engineers who designed it. And so, while the first Engineering Laboratory is a *designing* part of the factory, the second is a *testing* place.

The testing of the new cars is the last step and is one of the most interesting and exciting things we shall see.

A chauffeur from the factory is waiting for us now. He has come to take us in a company car to the factory. Are you ready?

IV

A MILLION DOLLARS FOR AN IDEA!

OUR chauffeur is a good driver. He dodges through traffic and speeds out one of Detroit's long straight boulevards. He tells us that he is one of the Test Fleet drivers.

"I just came in from the West Coast yesterday," he says. "There were five of us, each driving a new factory car. What a trip! I'm glad to be back."

He tells us about one day's trip. Early in the morning the cars ran into a blizzard. Later that same day, down from the mountains and on to the burning sand of the desert, they drove hour after hour under a blistering sun with the thermometer at 110 degrees!

He is certainly one of the men we shall want to talk to later when we are finding out how the new cars are tested.

Finally, near the edge of the city, he turns down a cross-street. He points to a graystone building with tall columns at the very end of the street.

"We're almost there. That is the Engineering Laboratory," he says.

He brings the car to a stop in front of the main entrance. The Engineering Laboratory looks like an ordinary office building. As

we get out of the car we can see tall smokestacks and low rambling factory buildings that seem to go as far as the eye can see. We are told that the factory itself covers acres of ground—more than many city blocks.

The man at the information desk takes us to an office on the second floor. A sign on the door reads "Vice President in Charge of Engineering." That is a long title, but the Chief Engineer is a very important man. He comes out to greet us.

"Good morning! We are mighty glad to have you visit our factory. I am sorry that I shall not be able to take you around the factory myself, but it is just time now for our regular Monday-morning meeting. While I am talking over some problems with my engineers, my assistant will show you the laboratory. I shall see you before you go."

We meet his assistant.

"The Chief never misses a Monday-morning meeting. They talk about ideas," he informs us as we walk down a long corridor. He opens a thick steel door for our first peep behind the scenes.

"This building is really an *idea factory*, you know. Sometimes we pay as much as a million dollars for a good idea."

A million dollars for an idea! He notices our surprise and smiles.

"By that I mean that it sometimes costs a million dollars or more to make a good idea *useful.* We have spent nearly two million dollars, for example, just to work out ideas for making our pistons better," he adds.

We go into a large room that looks very much like a school classroom. There are about five hundred men here, seated at long tables —drawing pictures! But these are not ordinary pictures, our guide says. This is the drafting room, where every separate part of the car is designed and drawn on paper. These drawings are the first step in building a motor car.

Let us peek over this man's shoulder. . . .

With his T-square and other drawing instruments he is designing

Drafting a model, actual size.

a radiator for a car that will be next year's new model. Over on the wall several men are working on a full-size drawing of the body for the same car, carefully writing down every measurement.

Our guide takes us over to a large box with sides made of glass. Inside the box is a tiny automobile that looks exactly like the model we have just seen drawn on paper.

"This is the wind tunnel," he explains. "For five years we have been studying different shapes of automobile bodies in this tunnel."

He shows us how a fan blows a steady stream of air through the tunnel in which the car stands. Charts on the outside of the wind tunnel show how much wind is pressing against the car.

"Have you ever put your hand out of the window of your car when it is going forty miles an hour?" he asks. "Well, the air presses against the whole car just as it does against your hand, only much harder, because the car is bigger than your hand."

The air *behind* the car sucks at it, too, to hold it.

"When an ordinary car goes fifty miles an hour," he explains, "more than half of the engine's power is really being wasted, for it is just being used to press the car through the air. Our engineers studied all their streamline designs in the wind tunnel and finally chose this one because it makes the air slide off the car as it goes along. This car goes much faster and uses less gasoline because the air flows past it instead of holding it back. This is why we call it an *air-flow* car."

A large corner of this same room has been set aside as a workshop

—the kind of workshop that any boy would like to have for his own. There are carpenters' benches, lathes, fine tools of all kinds, and heaps of smooth wood in all shapes and sizes.

In the center stands an automobile. But as we go closer to it we see that it is not really an automobile but a life-size model built entirely of wood. Some of the designers are still working on it. They are carefully smoothing off a curve on the fenders according to the measurements on the drawing. The model must be just like the drawing in every detail.

Our guide explains that this life-size model of wood is the second step in building a new car. Nearby is another model, not yet finished. The two automobiles are almost alike, but on one of the cars the fenders are a little more rounded and the radiator slants back a little more.

When the Chief Engineer and the other important men in the company decide which of the models they like better, the drawings will be sent down to the blue-print department. Here many copies, or blue-prints, will be made and sent to the Body Plant so that the workmen can start building the new bodies.

Other men in the drafting room are busy designing the new engine. A finished drawing of the engine with all its cylinders, pistons, its crankshaft and other parts, is made full-size on the paper. The whole drawing takes a sheet of paper twenty feet long! Do you wonder, then, that the blue-print department makes more than five miles of blue-prints every week?

When the engine drawings are finished and marked "O.K." the blue-prints go to the Foundry and Machine Shop, where models of the engine are built for testing. Before the new engine passes all the tests it must go through, probably many different drawings and many changes in plans will be necessary. Sometimes it takes months just to work out a new type of valve that will do its work better than the valves in last year's car. Every year the engine must be made better.

Just as we are leaving the drafting room the Chief Engineer joins us.

"I know you will be interested to see some of the tests we make on parts before the factory starts to build them for the new cars," he says. "Don't you want to come with me down to the testing laboratories?"

We pass through a doorway on which a sign says: "Mechanical Laboratory—No Admittance!" (It's fun to open doors that say "No Admittance!")

Here are all sorts of queer-looking machines. Almost in the center of the room a pit about two feet square has been sunk in the cement floor.

"We call this the *flywheel-buster*," the Chief Engineer explains. "This pit is lined with thick steel sheets and wooden planks about seven inches thick. There is a steel shaft in the center of the pit to which is attached an engine flywheel—one of the new ones just designed and built."

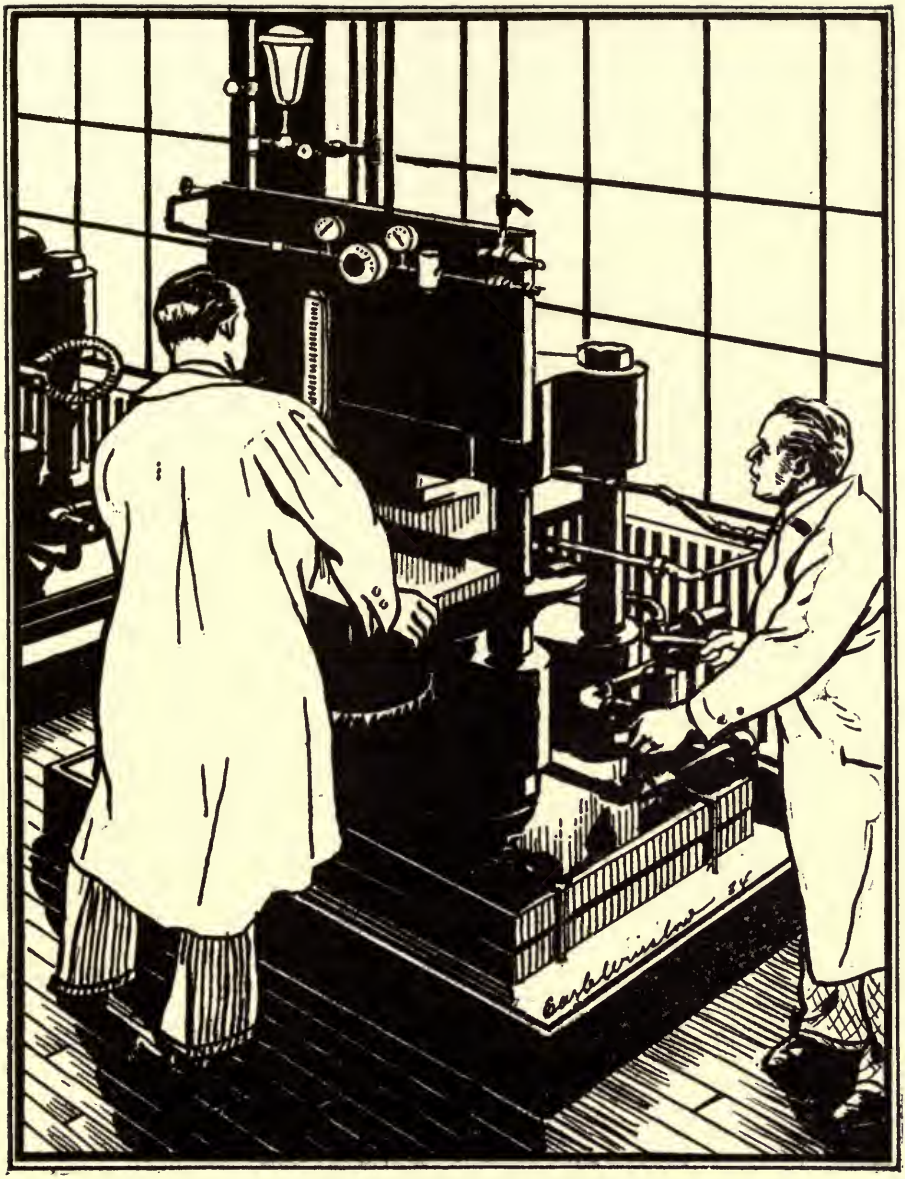
A flywheel, as you know, is the large heavy gear that is fastened to the rear end of the engine's crankshaft. In a car, at top speed, it revolves about 4,000 times a minute. In the testing pit, however, it is made to turn much faster—9,000, 10,000 and even 11,000 times a minute! Finally the strain is too much. The flywheel explodes with a noise like a cannon. Often the pieces fly off with such force that they sink deep into the wooden planks around the pit, and sometimes even into the steel lining of the pit.

The Chief Engineer tells us about this test:

"The *flywheel-buster* shows that the flywheel has been made to do its job well. We know that a flywheel which will not break down when it is making 11,000 turns a minute can certainly be depended upon to do its 4,000 revolutions a minute in a car."

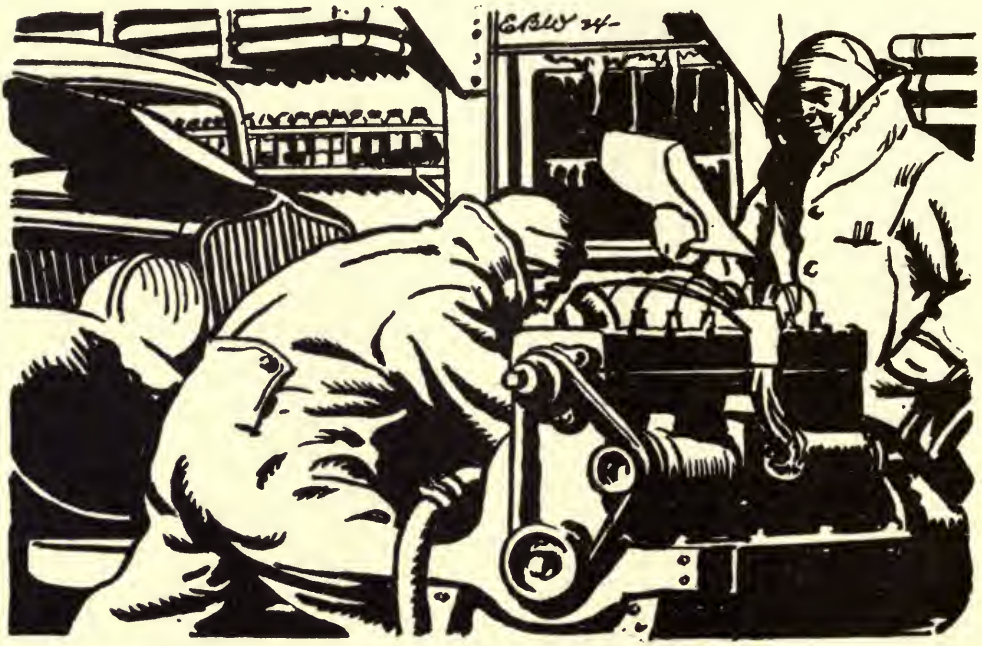
At one end of this laboratory is the Cold Room. A door almost one foot thick keeps warm air from getting in. Through the glass in the door we can see the thermometer inside. It reads 20 degrees below zero! There is an automobile in the Cold Room now, as well as several engines. Men in heavy fur coats and mittens are working inside, starting the engines and watching how they run in the bitter cold. Every now and then they step outside to write down something for their records . . . and to get warm!

Cars must be built to run in all sorts of winter weather. By studying the way the engine runs in the Cold Room, engineers can find ways of improving the different parts. The car must be able to start quickly even when the temperature is way below zero.



Hydraulic press testing machine.

The engine is not the only thing that is tested in these laboratories. Even little things like the horn must work perfectly. The Engineer opens a door marked "Horn Room." What a blast of noise comes out! Here are dozens of horns of many kinds, blowing



In the Cold Room.

all the time, day and night, until they break down. The horn that lasts the longest is probably the kind that the factory will put in the new cars. As soon as the door is closed the noise stops . . . or seems to. That is because the room is sound-proof.

A MILLION DOLLARS FOR AN IDEA!

One part of the Engineering Laboratory is for people who do nothing but think up new ideas and then see if they work. Many interesting things come from this department.

Now we enter another testing laboratory. Every test here is a "break-down" test. The Chief Engineer says:

"Perhaps you wonder why we spend so much time and money trying to break the parts we build so carefully. But if they are as good as we want them to be they won't break! That's what we want to find out."

One queer machine holds an automobile radiator, full of water, in its claws. It shakes the radiator back and forth, and up and down, just as a dog shakes a rat. After days or perhaps weeks of this rough treatment, the radiator will spring a leak. The place where it leaks is the weakest part . . . so the engineers then go to work to make this part stronger.

Over here is a transmission running day and night—first in "low" . . . then in "second" . . . and "high"—to see whether the gears will break down.

Nearby is a driveshaft that is twisted this way and that as it runs at top speed. Another machine turns the crank of a window-opener. Hour after hour the window opens and closes. Some day, weeks from now, it may jam. If it does not, then they know that it is "O.K."

Every part for the new car is tested, strained, and bent. Nothing "gets by" the engineers. The testing machines in this laboratory

give a car more wear than it would get in years of use and thousands of miles of hard driving.

But even this is not enough to satisfy the engineers. After the car has been built, they put it through even more surprising tests. We must be sure not to miss seeing these tests, later.

"What would you like to see next?" the Chief Engineer asks us.

We tell him that we would like to know how the engines are made.

"I will arrange to have you taken through the Foundry and Machine Shop so you can see for yourself," he replies. He calls to one of his assistants: "Ed, come here a minute. Take these boys through the Foundry and then turn them over to Joe, the Machine Shop foreman."

He introduces us to Ed. "Ed is one of the engineers who designed this year's engine. He can answer any question you can think of."

We thank the Chief Engineer and now Ed leads the way across the cement yard of the factory to the Foundry.

V

THE FOUNDRY

ED OPENS a door at the end of the Foundry building and turns to us with a smile.

"I hope you boys are wearing old clothes," he says. "Some parts of the Foundry are pretty dirty."

We tell him we don't care, if we can only see how the engines are built.

At the end of the building where we enter, there are rows of flat steel tables. They are built along the wall and also down the center of the building for quite a distance.

"This is the Pattern Shop," Ed explains. "You probably know that engine blocks are made by pouring molten metal into *molds* to give them the proper shape. When the metal cools and hardens it is what we call a *casting*."

We walk over close by one of the tables.

"Never call this a *table*," says our guide. "It is a *molder's bench.* This man here is a *molder*. Watch him at work for a few minutes and you will see how he makes the mold for an engine block casting."

Over the bench is a huge hopper filled with a mixture of sand

and clay. A compressed-air hose with a gun-type nozzle on the end is connected to the hopper and placed where the molder can easily reach it. The sand is damp and a little sticky—just about as sand at the seashore should be for building tunnels and things.

As a matter of fact, if it were not for the clanging of tools and the hiss of the compressed-air hoses all about us, it would almost seem like the seashore. For here are several hundred men busily making queer-shaped designs out of sand, just as small children make cakes at the beach by patting wet sand into their tin molds.

Ed laughs when we tell him what we are thinking.

"This is no beach party! Look at the big muscles on that molder's arms. You don't build up muscles like that patting sand cakes!"

The molder winks at us as he closes the clamps of a large steel frame that rests on the bench before him.

"That is called a *molding box*," Ed explains. "Look at the steel pattern, with its special curves and cross-pieces, that he is fitting inside the box. That pattern was made from the drawings that came from our department. Of course it looks very complicated, but you can see that it really is like an engine block in shape. See, there are the eight curved parts that will be the outside of the engine's cylinders."

Yes, we can see that much quite easily. Now the molding box is ready, with the pattern fastened inside it.

The molder puts the nozzle of the sand hose into it and presses the trigger. The sand shoots through the nozzle, filling the hollow

places between the pattern and the outer box. Then the molder pushes the whole box forward into a "jarring machine" that shakes it and packs the sand together solidly.

When the molder thinks that the sand *mold* is packed and stuck together so tightly that it will stand by itself, he loosens the clamps of the molding box and lifts the pattern out of the center. Then he also lifts up the whole box, and the mold stands all by itself on the bench—a perfect engine block built of sand!

Our engineer tells us that this mold is only half an engine block. Another mold must be made and glued to it for the complete engine block.

After the molder has smoothed off a few rough places on the sand mold, the men carry it to the drying oven.

"Easy there, men! Don't break it!" the molder warns them.

They lift it very gently and place it on a long tray that slides deep into the oven. Each tray holds several molds. We are told that they must stay in the oven for several hours until they are toasted through and through.

Another crew of men is just removing a tray full of "baked" molds. They are perfectly dry and nicely browned. Each mold is inspected and painted with oily *graphite* so that the molten metal will not stick to it.

Now the molds are ready to have the metal poured in. The men carry them, one by one, over to the middle of the Foundry floor. We will follow them to see what happens next.

Here we see our first *conveyor line*. Ed shows us just how the line works.

"In an automobile factory most of the parts are too heavy to carry by hand, so we have worked out a wonderful plan of conveyor lines. This one, as you see, is really an endless chain moving along slowly on rollers. You will see more conveyors wherever you go. Some are like this one. Others move on tracks overhead, carrying their loads with hooks or tongs."

On the conveyor line there are large iron boxes placed about six feet apart. The men set one of the baked molds in each box and cover it with loose black sand—all except for a small opening through which the molten metal will soon be poured into it.

As each mold comes along on the conveyor, we notice one of the men pricking it with something that looks like an ice-pick. We ask him why he does it.

"We have to make these tiny holes, or *vents*, so that the gases from the molten metal can escape. If we didn't, the mold might explode when the metal is poured into it."

Ed, the engineer, makes a suggestion.

"We could follow this mold conveyor on into the Foundry, but I think it would be better to go upstairs now to the gallery," he says. "Up there we shall be able to see how the metal is put into the *cupola*, or furnace, and we can also look down onto the Foundry floor and see the hot metal being poured into the molds."

So we climb a long steel stairway and walk down to the further

end of the building, finally coming out on a wide platform in back of the cupola.

The cupola is a special kind of furnace, built two stories high. At the second story, where we are standing, is a door through which the chunks of metal and coke are put in. Down below, on the Foundry floor, is another opening through which the molten metal is taken out.

We walk over to the outside edge of the platform and look down into the yard. Right below us, on railroad tracks, are freight cars loaded with *pig iron* and *scrap steel.*

Pig iron is gray. It comes in bars shaped like long loaves of bread. We are told that it is made by melting iron ore in a blast furnace as it comes from the iron mines. Each "pig" weighs about one hundred pounds.

"There are several kinds of scrap steel," Ed says. "In some factories they even cut up old automobiles and dump them into the cupola. We use short chunks of steel rails, sawed into pieces two feet long. You can see them down there in the freight cars."

A big hook or crane on the edge of the platform lowers its powerful magnet into one of these freight cars below. Five or six heavy bars of pig iron cling to it and are hoisted up to the platform. The crane operator swings the load around and dumps the iron into the hopper on the front of a small electric truck. In a very few minutes the hopper is loaded full.

"Take it away!" shouts the foreman.

The metal flows like fiery water into the bucket.

The driver runs the truck right up to the furnace door. The door opens. He tips the hopper forward. With a rush and a clatter the iron plunges down into the furnace and out of sight into the flames.

While the crane is busy loading the truck with scrap steel, men with wheelbarrows work fast, dumping loads of coke into the furnace on top of the pig iron. Coke makes a hotter fire than coal, and is always used for melting iron in a cupola.

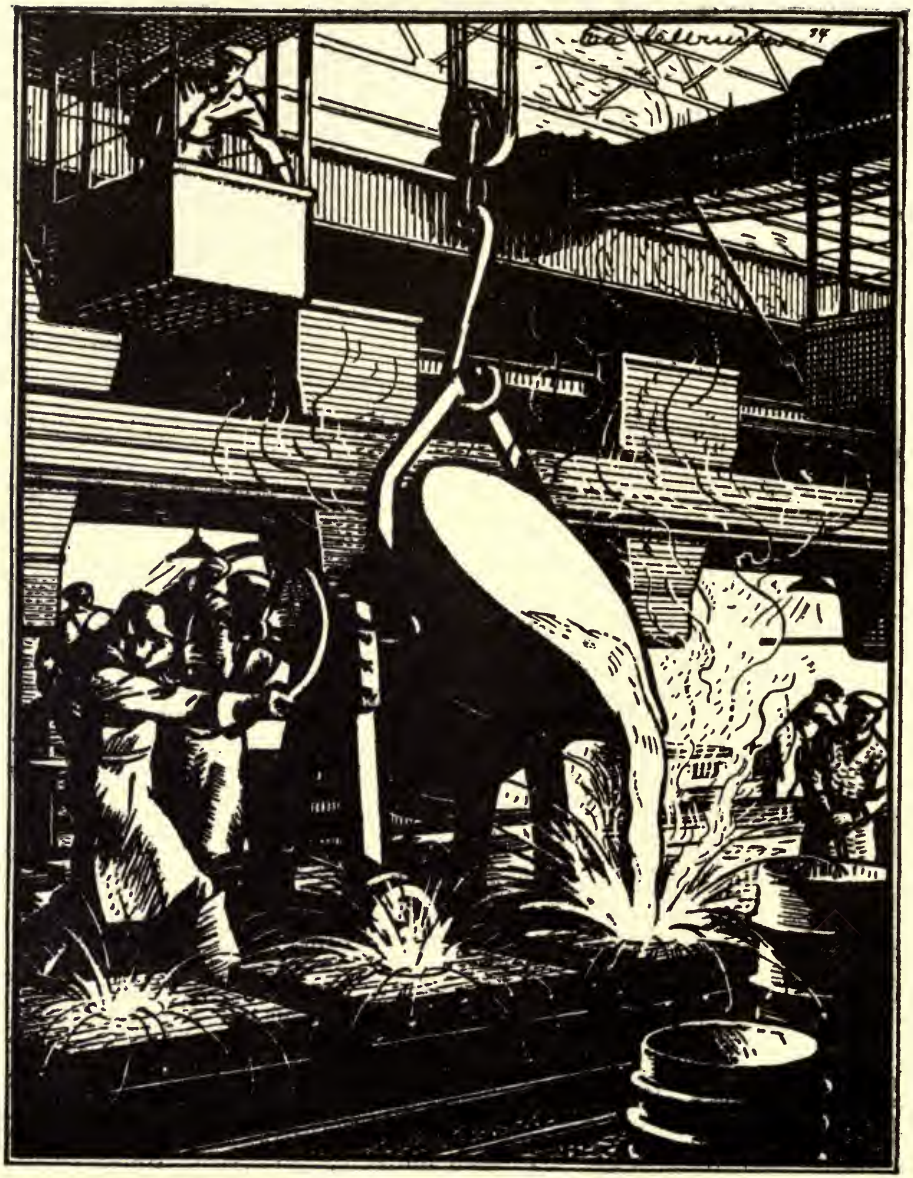
Heave away, men, heave away! Get that coke into the cupola before the load of scrap steel comes over!

Each time the door opens, long tongues of flame dart out as if to swallow men, wheelbarrows, coke and all. The men step back quickly after they have dumped their load, to get away from the heat.

Now the sturdy little truck rolls over with a load of scrap steel. "Heads up!" the driver shouts as one of the men gets in his way. Into the cupola goes the steel!

This is the way a cupola works, Ed explains. First a load of pig iron. Then a layer of coke. Then scrap steel. It must always be loaded right up level with the second-story opening. Down at the bottom of the furnace a fan blows in air to keep the fire burning at a hot temperature of more than 2,000 degrees!

Soon the metal inside the cupola becomes red hot. Then white hot. As it melts, it starts to flow like fiery water, down through the layers of coke to the bottom of the furnace. Standing on the inner



The men pour the hot metal into the molds.

edge of the platform we can look down and see the workmen drawing off the molten metal from the opening at the bottom of the cupola.

When they pull the lever, the door slides open and out comes the molten metal, down into a large bucket that hangs underneath. The metal splashes into the bucket. Sparks fly all around the men and onto the thick clothing they wear for protection.

Sometimes we cannot see very clearly into the Foundry below us because of the thick blue haze of smoke and dust. Gas fumes from the hot metal fill the air. The men shout directions to one another above the noise of the cranes and the hiss of molten metal. Streaks of blue flame flash through the haze. Sparks shoot up like rockets from the flowing metal.

Smaller buckets, hanging from heavy hooks on an overhead track, move up to the giant cupola bucket. The big bucket tips and fills them with red-hot liquid metal. Off they go, over to the conveyor line on which the molds are creeping along down the center of the Foundry floor.

As the buckets reach the conveyor line, they pour their metal into each mold as it passes by. The sparks from the splashing metal fly all around the men.

We come down now from the platform so that we can see just how the pouring is done. As the metal flows into the mold, darts of flame burst through the loose earth that covers the molds. As the molds move on, the flames die down. Sometimes the boiling metal

bubbles over, sending up thick curls of smoke like a little volcano. Jets of gas and smoke hiss from the holes the men pricked in the sand. This is certainly a sight worth seeing, even though we are already covered with dust and sooty smudge!

One after another the molds are filled with molten metal and move on their conveyor line over to the other side of the Foundry. As they crawl slowly along, the metal inside begins to cool and harden.

Workmen with long tongs meet the molds as they come along. They take off the top of each and lift out the huge block of cast iron with tongs attached to a small crane. Then they knock off the loose dirt and sand from the casting.

"You notice that the men don't get any closer than they have to," Ed exclaims. "That casting is still red hot. Feel the heat from it, even where we are standing!"

The workmen swing the crane around and lower the engine casting onto another conveyor. We follow it around a corner into another section of the Foundry. What a noisy place this is!

"The Vibrating Room," Ed shouts in our ear. "This is the Vibrating Room."

Here each casting is hoisted up and set between the steel jaws of a vibrating machine. With a noise like a rivet-gun, the machine jars and jiggles the casting of the engine block back and forth.

Almost all the sand that has stuck to the casting is shaken off in this way. The little that stays on is cleaned off with a compressed-

air gun, just as men clean dirt from the face of a building with sand blasters.

Each casting is now placed on still another conveyor that runs upward and disappears through an opening in the wall of the Foundry.

"From here, the engine castings go over to the Machine Shop," Ed tells us. "If you have seen everything you wanted to see here in the Foundry, we will cross over to the Machine Shop. I will get Joe, the foreman, to show you how these castings become automobile engines."

We are glad enough to get out of the heat and smoke and dust! We breathe the fresh air deeply on our way across the yard to the Machine Shop.

VI

THE MACHINE SHOP

"WELL, here we are," says Ed. "There is Joe, the foreman of the Machine Shop, looking over his blueprints."

Joe sees us and walks over with a blue-print in his hand. He shows Ed the drawing and says, "I wish you fellows over in the Engineering Lab would make your drawings so we can figure them out!"

Ed knows he is joking. "That's one of the best drawings you ever saw, and you know it!" he replies. He tells Joe that we have just been through the Foundry. "Now they want to see how you build the engines here in the Machine Shop. Will you take them around?"

"Sure!" Joe shakes our hand. "But of course you know that you would have to spend a long time here to really see how all the engine parts are made. The engine is the heart of the automobile and is very complicated. It won't take long, though, to show you the important steps in the building of an engine, from the time we get the rough casting until the finished motor leaves this building for the main assembly line."

We tell him that is just what we would like to see.

"O.K." he says. "Follow me."

We say good-by to Ed and follow the Machine Shop foreman down an aisle, picking our way through neatly piled stacks of parts and materials.

We stop by a pile of engine castings.

"These have just come over from the Foundry," says Joe. "Perhaps they are the very castings you saw being poured into the molds. See how rough they are now. They could not be used like this, of course."

A little further down the aisle Joe says, "Come on, boys. My men are just getting ready to put some castings into the drill."

The *drill* is a big machine that reaches up almost to the ceiling. Joe says it weighs many tons. Two men, with the help of an overhead crane, are lifting two engine castings from the pile, one at a time. They set them carefully into the frame of the big drill. The arms of the machine close in on the engine blocks and hold them tightly in place.

"O.K.!" shouts one of the men. The other man turns an electric switch, the heavy gears of the machine whir and grind, and large drills bore down into the engine castings, boring out the cylinders into perfectly shaped holes just the right size for the pistons. Then the castings move on, and two others are hoisted into place for boring.

We follow them to the next machine. This one is even larger than the first. It is a rotary drill, we are told. Not just two engine blocks, but *six* at a time, are placed in this drill. The operator throws the

switch and the upper part of the machine comes down. In a single operation it drills 127 holes in the six engine castings!

It seems as if the engine blocks were becoming riddled with holes.

"Oh, no!" says the foreman. "Each hole has a special purpose. These holes here are for the *valve stems*. These are for the *lugs* that hold the top of the engine, or *cylinder head*, to the block. Some of the other holes are for fastening on such parts as the *carburetor*, *generator* and *distributor*."

Now the engine blocks go into another great machine called a *rotary miller*. This machine shaves the ends of the engine blocks smooth, just as a carpenter's plane shaves a block of wood. Each casting is then turned up on its end so that the miller can smooth off the top and bottom.

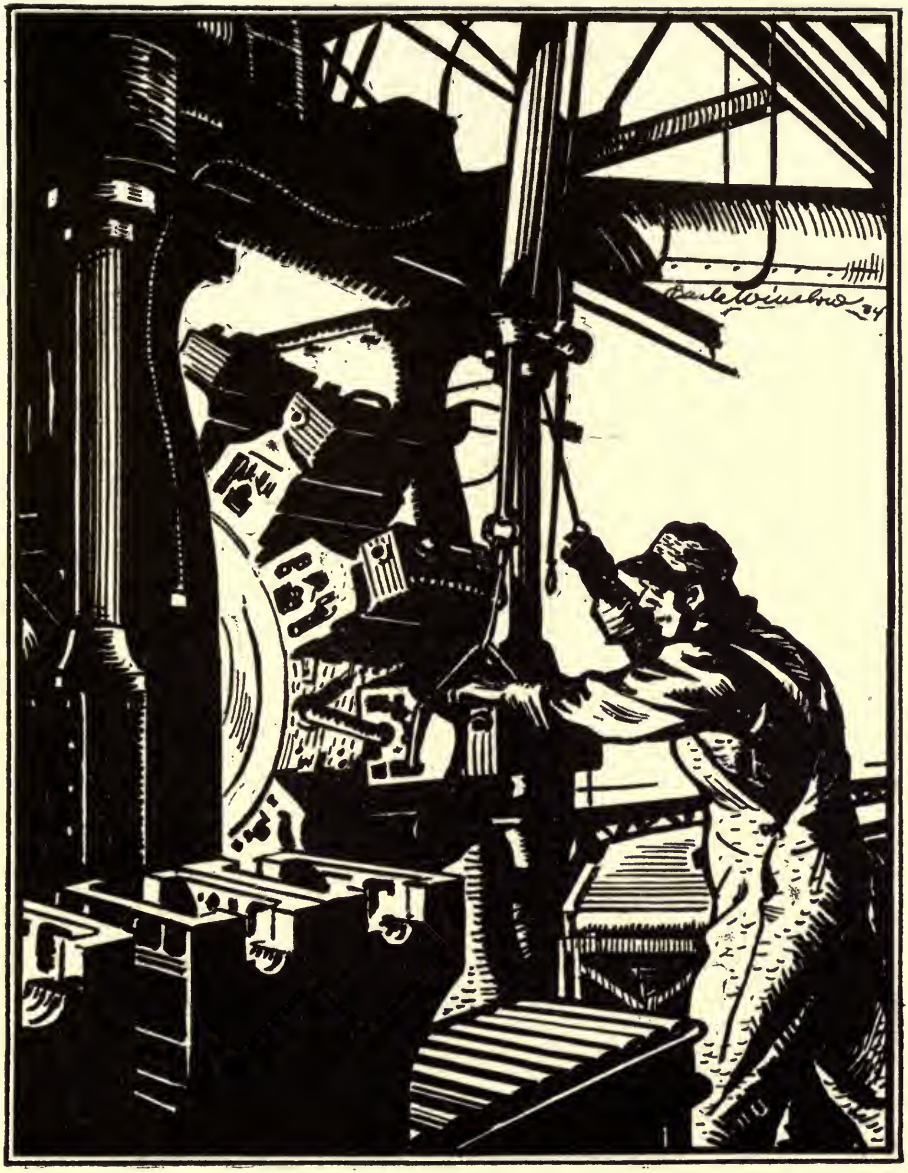
Now our casting looks more like an engine. An assistant foreman inspects each one.

"This one is O.K., men," he says. "Take it away."

The men hoist it up into the air and place it, *upside-down*, on a low four-wheeled wagon.

"We call this little wagon a *dolly*," Joe explains. "It rolls along the engine assembly line very slowly, so that the men have time enough to install the parts as it goes along.

"We shall come back to it in a few minutes. First, I want to show you how some of the parts themselves are finished off. Come this way, please."



Rotary milling machine.

We walk over to another section of the Machine Shop.

"This is where we make the crankshafts," Joe says. "Here is a pile of them just as they have come from the forge."

The *forge*, he tells us, is a giant machine in which a trip-hammer, weighing several tons, drops down and presses hot steel bars into special shapes. When the crankshaft first goes to the forge it is nothing but a thick straight bar of steel. After it has been heated red hot, a workman picks it up with tongs and thrusts it into the forge. The operator throws the switch. Bang! Down comes the hammer onto the steel bar. Each time it hits, it presses the angles, or *cranks*, into it.

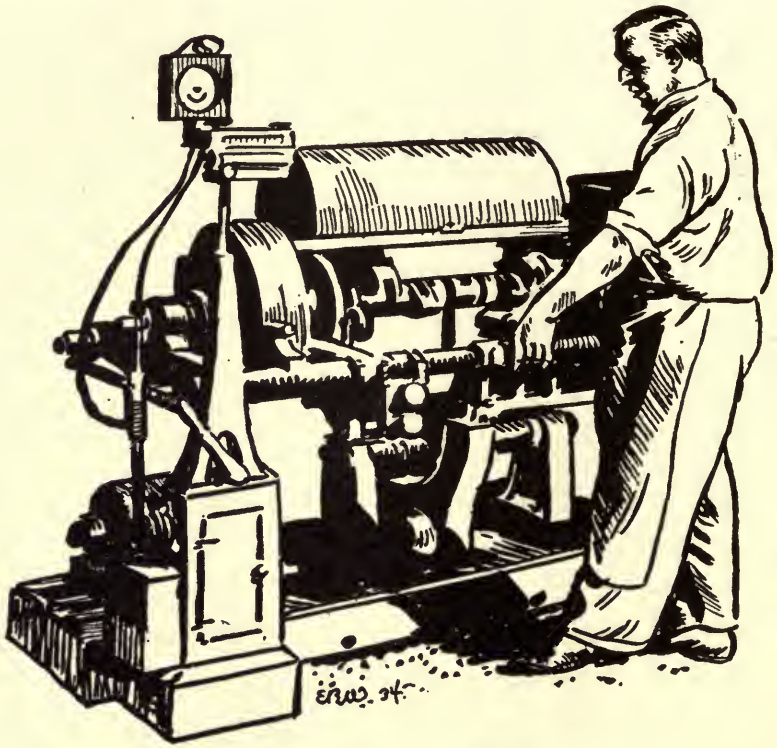
Then, Joe explains, the man with the tongs quickly turns the crankshaft on its side. Once again the hammer falls. Bang! And the rest of the cranks are bent. Although very rough, the crankshaft is now about ready. It is sent over to the Machine Shop to be finished. Now we can see how it is done.

"The finishing of the crankshaft is one of the hardest jobs in the building of the whole car," Joe informs us. "It weighs about one hundred pounds, yet it must be balanced so perfectly that it can turn at terrific speed without the slightest vibration. If the crankshaft were not balanced properly it would actually tear the engine to pieces in a very short while."

We watch the crankshaft as it is given its tests for balance. We see it turned over and over on a special machine—slowly at first, then fast—while fine instruments show whether it is truly balanced.

The trip-hammer drops on to the crankshaft.

"Next to balance," continues Joe, "the most important thing is the *bearings*, the surfaces where the pistons are attached to the



Crankshaft balancer.

crankshaft by their *connecting-rods*. There are also the *main bearings* which hold the crankshaft as it turns inside the engine."

The foreman of the crankshaft department shows us how the crankshaft is turned over and over on a small lathe while his men

polish each bearing with emery cloths. They start with rough emery cloth, changing to finer and finer cloths as the bearings are ground smoother.

After the bearings have been smoothed and polished they are measured with an instrument called a *micrometer*. If they are as much as one-and-a-half *thousandths* of an inch out of the way, they must be polished still more!

Joe shows us his ruler and measures off one inch on it: /————/

"If you should try to divide one inch into a thousand equal parts, or even a hundred, you would understand how carefully the crankshaft is made," he says.

The thousandth part of an inch is not nearly as thick as a hair, he tells us!

Now Joe takes us over into another department, where the pistons are being finished.

"This is one of the queerest machines ever invented," he exclaims. "It is called a *piston-turner*. See what happens to the pistons as they roll along toward it in this narrow trough."

Along comes a piston. A claw reaches out and grabs it tightly. The claw then drops the piston into clamps inside the machine. The clamps turn the piston slowly around while the machine grinds it smooth and shiny. Sharp steel cutters make the four grooves at the top of the piston, into which the *piston-rings* will be fitted.

This done, the left claw of the machine lifts the piston out and drops it gently onto an endless belt that takes it away.

This wonderful machine looks for all the world like a fat ugly spider lying in wait for morsels of steel to devour. After it has snatched them and gnawed them, it throws them aside and reaches for the next!

As we pass on toward the engine assembly line we have to make a detour around a large boxlike machine.

"This is the *ice-box* for *valve inserts*," the foreman tells us. He shows us what a valve insert is. This small round circle of metal is the "seat" on which the valve fits when it closes.

We want to look at the valve insert more closely, so we reach for one as it comes out of the ice-box. Joe shouts a warning: "Don't do that! Don't touch it!"

Then he says, "I didn't mean to scare you, but that piece of metal is 100 degrees colder than zero. You didn't know it, and I should have told you. Metal that cold can burn your fingers as badly as red-hot metal!"

He explains how metal shrinks and contracts when it is cold. When the valve insert is put in place in the engine block it gradually gets warmer and swells so that it fits very tightly.

"Now we will go over to the engine assembly line and see how the engines are put together," says Joe.

VII

BUILDING THE ENGINE

NINETY HORSE-POWER IN HARNESS

HERE we are again at the assembly line where the different parts of the engine are put together.

As each *dolly* rolls along with its engine block, still upside-down, it comes to a table where pistons have been carefully weighed and balanced in sets of eight.

"Matched pistons work much better than just *any* eight pistons you might happen to choose," Joe explains.

When the pistons and their connecting rods have been fitted into the cylinders, the crankshaft is attached, then the valves and other parts, until finally the engine's parts are all in place. The last job is to seal the *crank-case* shut. The engine is then lifted by a hoist and put back on the moving assembly line right-side-up.

The eight spark plugs are screwed in place. Quickly the men bolt on the carburetor, generator, distributor, and various other parts . . . and now the engine is just about finished. It moves on to the *block-test* room.

A large part of the Machine Shop has been fenced off for the

block tests. Here we see about two hundred finished engines roaring away, each one bolted to a low stand. A pipe comes up through the floor by each engine, bringing water to keep the engine cool, for it has no radiator yet.

Assembling the engine.

"See this other small pipe-line," says the foreman. He touches a small iron tube that is connected to the carburetor.

"For the block tests the engines are not run on regular gasoline, but just plain city gas—the same kind of gas that your mother uses

to cook with in her kitchen. Each engine is run for about an hour and a half to break it in. When an engine is first put together, all the parts are very tight and stiff—especially the bearings. The block test takes the stiffness out of the engine."

Engineers walk from one engine to another, checking the operation of each one with special instruments. Two hundred engines running in one room make a lot of noise! But there are no fumes, for the exhaust gases are taken away by pipes that disappear through the floor.

As soon as the engines have completed their block tests they are unbolted from the stands and taken to the *dynamometer* room. Here each engine goes through very special tests to find out its exact horse-power and other things. The dynamometer test is an important event to us who have seen the engine being built—for it is now going to be run on gasoline for the first time, just as it will have to run when it is put in the car.

We cannot help wondering what might happen if it refused to run because it had not been put together right!

Joe laughs. "Don't worry about that! It always *is* put together just as it should be."

Now comes the real test! Of course Joe knows what he is talking about, but, we wonder, will the engine really go? The engineer presses the starter button with his hand. Whirr! Whirr! There it goes! The engine roars to life. Joe looks at us and grins. Even though we knew it would start all right, it is thrilling to find that

The dynamometer test.

the casting which we saw poured into the mold is now completely assembled and actually running!

The operator opens the throttle wider and wider. Now the engine is firing away in fine fashion—"hitting on all eight." He checks the dials of the many instruments on the wall very carefully. They tell him the things he wants to know about the engine. He tries each of the transmission gears to see how much power he gets in "low," "second," and "high." Then, for good measure, he shifts into reverse.

He closes the throttle so that now the engine turns over at just an "idling" speed and writes out his report. The foreman of that department comes over and reads the engineer's report which he has just finished.

"Everything O.K.?" he asks.

"O.K.," his engineer replies. "I've tuned her up so she runs like a watch!"

The foreman, with a small steel punch, stamps a dash (like this –) on the side of the engine block right after the engine's factory number.

Joe says: "Every engine, as you know, is given a number of its own. When you get home look at the number on the engine block of your car. See if you can find the dash that was stamped on after it passed its test."

Now the engineer snaps off the ignition switch, unfastens the connections . . . and the test is over. His helpers hoist the engine up to

a conveyor line that takes it over to the main assembly line to be installed in a chassis.

"Well, there she goes, boys . . . all finished!" Joe exclaims. "In about an hour it will be driven off the assembly line . . . the most important part of a brand-new car. We are mighty proud of the engines we turn out. Now that you have seen how we do it, perhaps you know why!"

Joe asks us if we have seen the main assembly line yet. We tell him that we have not—that we want to save that until we have seen almost everything else.

We thank him and leave the Machine Shop.

VIII

THE BODY PLANT

ONE of the company cars is waiting for us in the yard back of the Engineering Laboratory.

The driver opens the door for us and says: "The Chief Engineer asked me to drive you over to the Body Plant. It is about two miles from here. He has already telephoned the Superintendent to tell him you are coming."

We get into the car. As we head out through the gate a watchman stops us and asks to see the driver's pass. He shows the watchman his card and says, "Going out on company business."

"O.K. Go ahead," the watchman replies.

"The watchman really knows who I am," says our driver, "but it is a rule here that no one may enter or leave through the gateway without showing his pass. Even the workmen have badges with their numbers on them."

Once again we are in the city streets. Suddenly the driver says, "Here comes one of the trailers from the Body Plant with a load for the assembly line."

On the long trailer are six freshly painted automobile bodies. The truck driver waves his hand as he passes.

Straight ahead of us is the Body Plant. What large buildings! They cover a number of whole city blocks! Here, too, our driver has to show his pass at the watchman's booth.

We enter the first building and go to an office door that says "Superintendent." The Superintendent is the man who is in charge of everything here.

"I have been expecting you," he greets us. "I understand that you want to see how automobile bodies are made. I will get my plant manager, Bill, to take you through."

He presses an electric buzzer on his desk. Only a few seconds and Bill comes in.

"You have chosen a good time for your visit," he exclaims after we have been introduced. "We are running full blast right now to turn out enough bodies for the assembly line."

He turns to the Superintendent. "Shall I take them to see the presses first, boss?" he asks.

"Yes," replies the Superintendent. "Show them the whole plant —the presses, the welding shop and the paint shop."

We thank the Superintendent and start off with Bill. As he leads the way he says, "You probably know that our automobile bodies are made entirely of steel so they will be very strong. In the building we will visit first, you will see how the steel panels of the bodies are pressed into shape."

We go through a doorway and into a shop where huge machines tower above us right up to the ceiling, three stories high. We are

told that these are heavy-duty presses. Their steel framework rises like giant trees in a forest. We follow the plant manager over to one of the largest of them all.

"This is the press that stamps out the rear fenders," he explains. "See how the men lay steel sheets in one side, and how the sheets come out as fenders on the other side."

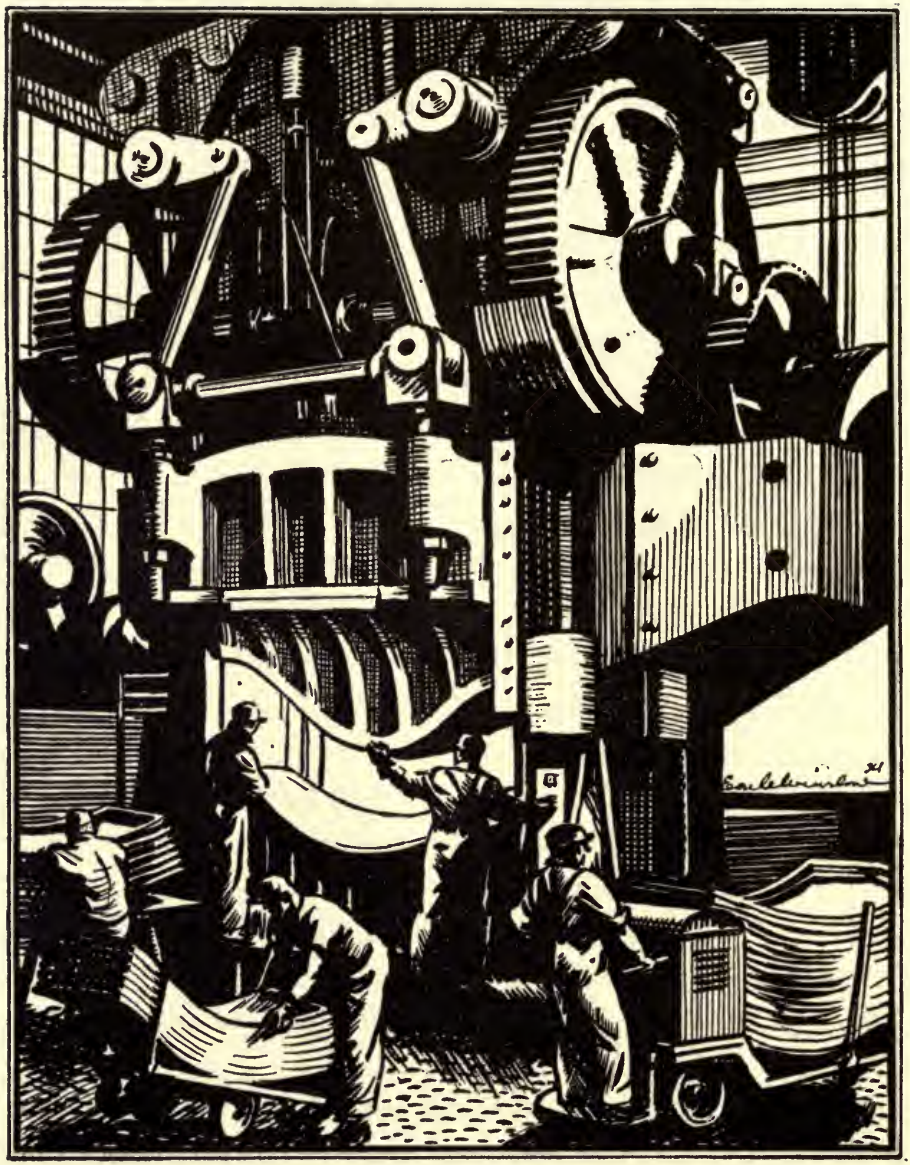
What an enormous machine! It takes a crew of five men to run it. Bill shows us the *die*, or pattern, that gives the steel its shape. The lower half of the press is dug out hollow in the shape of a fender. The upper half bulges out and fits into it.

Let us get closer so that we can see how it works. Two of the men place a steel sheet in the press. The third man works the controls. Down comes the heavy press, shaping the steel into the hollow pattern beneath it. Then it rises. Quick as a flash the two men on the other side of the machine take out the finished fender and lay it aside.

Again and again the press comes down, and rises, as the men feed it the steel sheets. The pile of finished fenders on the other side of it grows higher and higher.

Here comes a tractor scooting along through the press shop, dodging in and out between the great presses. Behind it is a trailer. The tractor stops while the workmen pile their finished fenders on the trailer—and off it goes!

As we watch the press at work we notice that as soon as the men slide the sheet of steel into place, one of them quickly presses a but-



The giant press stamps out the fenders.

ton on the machine. We ask him if the button has anything to do with the operation of the press.

"Well, not exactly," he replies. "That button is merely a safety control. You can imagine what would happen to our fingers if the press should come down on them! The button is for our protection. Until we press it, the operator's controls are locked. You can bet that we never press it until our hands are safely out of the way!"

Bill explains that there are safety devices like this on all the machines that are dangerous. That is one reason why there is hardly ever an accident in this plant.

We walk through the building to see some of the other presses at work. Some make front fenders. Others stamp the steel sheets into doors for the automobile and the different sections, or panels.

"The presses all operate the same way," Bill tells us. "The only difference is the die. The die must be shaped exactly like the part that is to be made on it, just as the molds you saw over in the Foundry. Because the steel is thinner, it can be pressed into shape instead of being poured into molds to cool and harden."

As we walk along we are careful to keep out of the way of the tractors. They whizz by us with their loads and climb a ramp to the floor above, where the welding machines are.

"Now we will go up to the welding shop," says our guide. "There we will see how the steel panels are put together into automobile bodies."

On the way up he says: "Of course you know what *welding* is.

Two pieces of metal are joined by melting their edges together with heat. A welded joint is even stronger than the rest of the piece if it is done as it should be."

We tell Bill that we have seen workmen welding trolley-car tracks in the city streets with a small torch that shoots out a hot blue-white flame.

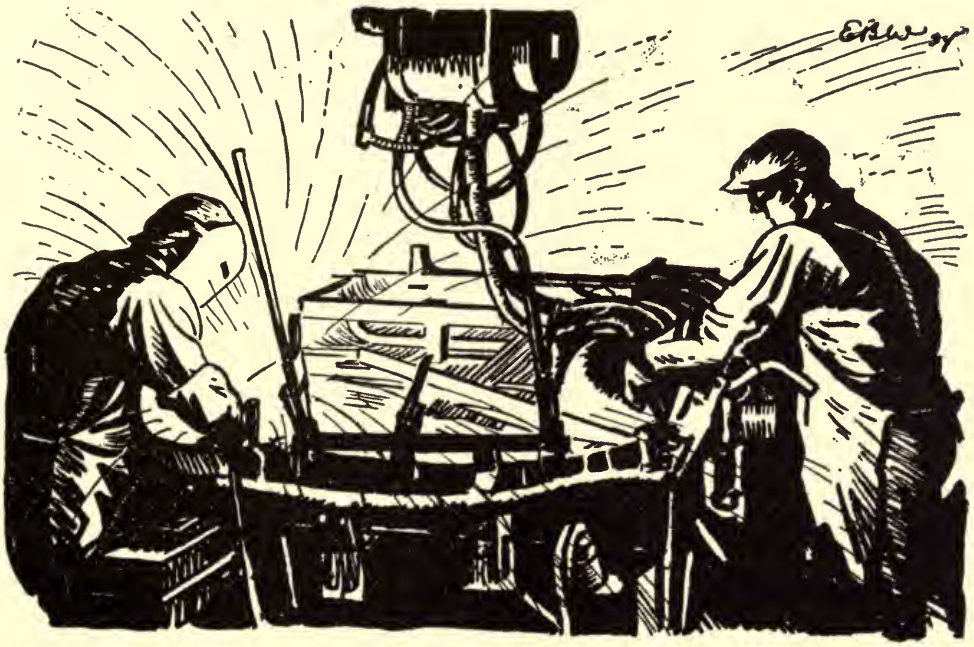
"That's right," says Bill. "Only here in the Body Plant we do our welding with electricity."

Here we are in the welding shop. The tractors are unloading their panels and fenders beside the low wide welding machines. We stop long enough to see how two of the side panels of the body are welded to the rear panel. When the men have clamped them in place, they step back quickly. The operator throws the switch. Psss! Psss! The electric current shoots through, sending a shower of sparks everywhere. For twenty seconds the current sizzles through the joints of the steel panels. The sparks fly into the air just as they do from a whirling Fourth of July pinwheel. Finally the operator closes the switch and now the panels are joined firmly together.

"This is the rear half of the automobile body, as you see," says Bill.

The men remove the partly constructed body from the welding machine and put it on a short conveyor line. Along the edges where the panels have been joined there is a rough seam. Men with electric polishing wheels grind down the roughness. Bzzz! Bzzz! Now the seams are so smooth we cannot see where the joint has been made.

An overhead crane lifts the body from the conveyor line and lowers it into another welding machine. Here the front sections of the body are added.



The operator of the welding machine throws the switch.

The steel body is now almost finished, except for doors and the top. An inspector examines the seams carefully and signals the men who are operating the crane.

The gears of the hoist grind away once more. Now the body is being lowered through a large square hole that has been cut in the

floor. A fence has been built around the pit so that the workmen will not fall into it. We walk over and look down.

"If we walk down the stairway beside the pit," says Bill, "we can see what happens to the body when it reaches the floor below us." Down we go!

As each body comes down from the floor above, the workmen put it on an endless conveyor track that rolls through the building on its small geared rollers.

"This is the starting point of the longest conveyor line in the whole automobile factory," says our guide. "As you see, the bodies are put on it about six feet apart. They are now on their way to the paint shop."

The long line of bodies creeps slowly along as far as we can see. We walk beside them until we come to a large square oven which is built right over the track on which the bodies are moving. One by one the bodies disappear into the oven.

"In this oven," the plant manager explains, "each body is sprayed with live steam to clean it thoroughly."

We walk around the oven and join the conveyor line on the other side.

What is this! We can scarcely believe our eyes! The line of bodies is climbing up a steep grade! They go up . . . up . . . up . . . through the ceiling to the third floor above the one on which we are standing! The conveyor line, with its framework slanting upward, higher and higher, makes us think of a roller-coaster.

We tell Bill that it would be fun to climb into one of the bodies and ride up the steep cogwheel track.

"No siree!" he exclaims with a smile. "We can't take any chances like that. We'll *walk* up! Come along, up this stairway."

The men who spray on the paint wear queer masks.

Three floors higher up we meet the bodies as they reach the top of their climb. The conveyor track comes up right through the floor and levels out once again."

"This is the paint shop," says Bill.

What a busy place it is! The bodies move along like a long line of cars in one-way traffic.

The foreman of the paint shop comes over to speak to Bill. "We are putting through five hundred dark blue sedans on this line today," he says.

The bodies move along slowly and disappear, one by one, into large square paint booths where the paint, or *lacquer*, is sprayed on to them. The men who work the sprayers wear queer masks over their faces to protect them from the fumes of the paint. The masks have snouts over the mouth and glass goggles for the men to look through. What frightening masks they would be for Hallowe'en!

The men spray many coats of lacquer on the bodies as they creep along from one booth to another. After the bodies leave each paint booth they pass through ovens in which the lacquer is baked dry and hard.

"The ovens are heated by twelve large oil burners," Bill tells us. On the outside of each oven is a thermometer. How hot it must be inside! This thermometer reads 475 degrees!

Each time the bodies pass through a drying oven, men with hoses and sponges wash them and rub them down. This makes the paint very smooth. The water is drained off in gutters.

"Come over here a minute, boys, if you want to see something funny," says Bill.

We go over to a big steel tank that looks very much like an indoor swimming tank. The sides are about four feet high and the

bottom is covered with water about six inches deep. Two men with rubber boots on stand in the water at one end of the tank and swish it back toward the other end with brooms. What a queer thing to do, for the water runs right back again! But still they keep on swishing, not the least bit discouraged.

They remind us of the story about old King Canute who stood on the beach at the seashore trying to sweep back the tide with his broom!

"These men are cleaning the water that has been used to wash the newly painted automobile bodies," our guide explains. "The water we use costs us thousands of dollars each year. By swishing it and straining it through filters in this tank the men make it clean enough to use over again for washing more bodies."

Now we go down to the floor below and watch the tops of the bodies being pressed into place, and the dashboards put on.

Another stairway brings us down into a big room where the upholstery for the body is made. Here are the cushions for the seats, the floor rugs, and the cloth for the inside of the body.

Here, too, are a great many sewing machines, but surely they are the queerest sewing machines we have ever seen!

"They are called *blind stitchers*," says Bill, "because they sew the cloth so that the stitches are hidden from sight."

The bodies are almost finished. The glass windshield and windows are slipped into place, and the doors are fastened on. Near the end of the conveyor line the bodies are given a last coat of misty

lacquer. They go through their last drying oven and then are polished with an electric wool wheel.

Now they are finished. How shiny they are! We hope that the people who are going to buy these dark blue sedans will keep them just as shiny as they are now!

"Well, boys, there they go," says Bill, as we watch the workmen lifting the finished bodies from the conveyor line. They put them on trailers that are waiting by the loading platform. "From here they go over to the Assembly Plant."

We ask Bill where the glass windshields and windows are made.

"We buy them from the Glass Factory in Pittsburgh," he replies. "They are all safety glass—the kind that doesn't shatter if the car happens to be in a smash-up. If you are ever in Pittsburgh you should make a trip through the Glass Factory. It is a very interesting place."

"I suppose you want to go to the Assembly Plant," Bill adds, "and see how they put cars together on the famous Assembly Line."

We walk back to his office.

"My assistant tells me that your car has just come back to take you over. The driver is waiting for you outside in the yard, so I'll say good-by. I hope you enjoyed your trip through the Body Plant."

We thank Bill and go out to the car that is waiting to take us to the Assembly Plant.

IX

THE ASSEMBLY LINE

HAVE you ever seen a beehive? Have you ever stood close by one and heard the droning buzz of the bees as they zoom to the hive from all directions laden with honey, and dart out again to find more?

That is what we think of as we cross the yard to the Assembly Plant, for it is quite like a beehive.

Instead of bees, however, little tractors dart here and there, humming along through the yard, towing trailers loaded with axles, transmissions, radiators, wheels and other automobile parts. When they have unloaded their cargo on the platform of the building, they buzz off again like bees to get another load.

Big trucks rumble along up to the platform, unload, and are off again. Some of the trucks have trailers more than thirty feet long. These are the trailers that bring automobile bodies over from the Body Plant.

Everywhere there is something going on. The Assembly Plant is half a mile long, all under one roof! The receiving platform runs along the entire length of the building.

Tom, the chief foreman, meets us as we go up the steps at the end of the receiving platform.

"The Chief Engineer told me that you were coming over. I shall be glad to show you around the Assembly Plant," he says. We follow him across the end of the building toward the main assembly line.

"As you see," Tom explains, "the main assembly line runs along the entire length of the building. It is really an endless conveyor track, half a mile long, traveling on rollers. It moves forward all the time at a speed of eight feet a minute. Although it never stops, except in case of an emergency, it moves slowly enough to give each group of workmen just enough time to put certain parts in place in the chassis before it passes by them."

Here we are at the head of the main assembly line. It seems almost like a gently flowing river, never stopping and never changing its speed. At many different points in the line it is joined by long *feeder* lines, which move across the building bringing all sorts of parts from the receiving platform to the main assembly line. These feeder lines are like brooks flowing into the river.

Some of them are endless chains like the main assembly line, moving along the floor on geared rollers. Others run overhead, on tracks, carrying their loads suspended on hooks or tongs.

"There are eighteen miles of conveyor lines in this building alone," the foreman tells us. "Some move at the same slow speed as the main line. Others travel faster."

We notice that not all the materials move on endless chains. There is a fleet of small electric trucks or tractors like those used in railroad stations for moving baggage. Most of these tractors are built with low platforms on which the automobile parts are loaded. Some of them tow loaded trailers about the building. They rush about here and there. "Toot! Toot!" go their horns, to warn workmen to step out of their path.

"There is a great deal to be seen in this building," says Tom. "Of course the most important thing is the assembly line itself. Suppose we start at the very beginning and follow it along step by step to the end."

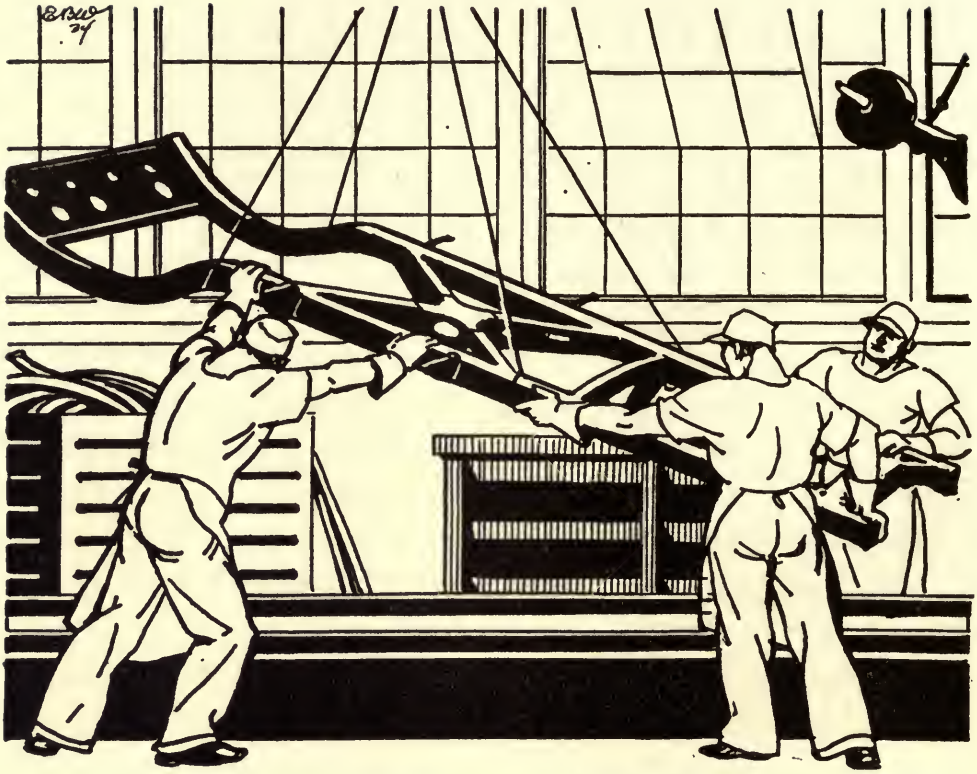
That will be fine, we tell him.

Where the assembly line starts there is a high pile of chassis frames. One by one the workmen put them on the moving track, letting about six feet of the assembly line pass by before they put the next automobile frame on.

As the frames start their half-mile journey down the length of the building, one behind the other, more frames are being brought over to the workmen from the other side of the building on an overhead conveyor.

After we have watched a number of chassis frames being laid in place, Tom suggests that we choose one of them and follow it on its complete trip.

"That is the best way to see what happens on the assembly line," he says. "You will see this frame built up, part by part, into a chassis

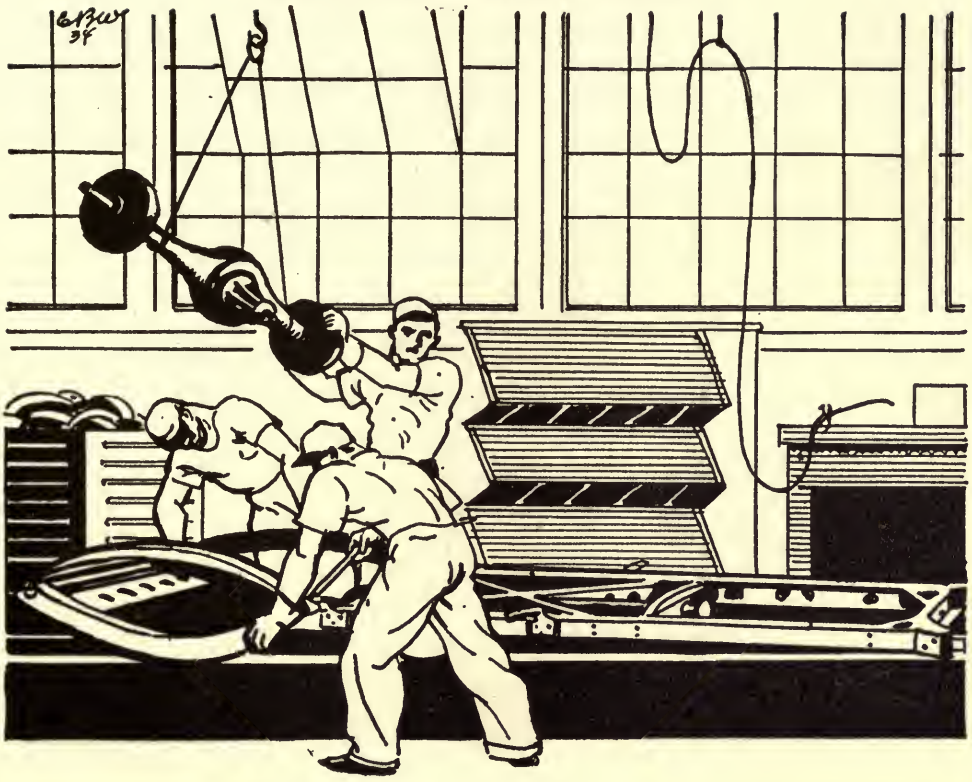


The frames are put on the assembly line upside down.

and then into a finished automobile. In about fifty minutes—less than an hour—it will be driven off the end of the assembly line under its own power, ready for a buyer."

"The frames are put on the assembly line upside-down," Tom explains. "This makes it much easier for the men to put in parts that are really *under* the chassis. Later on they turn it over."

We start to follow one of the frames as it creeps along. First the

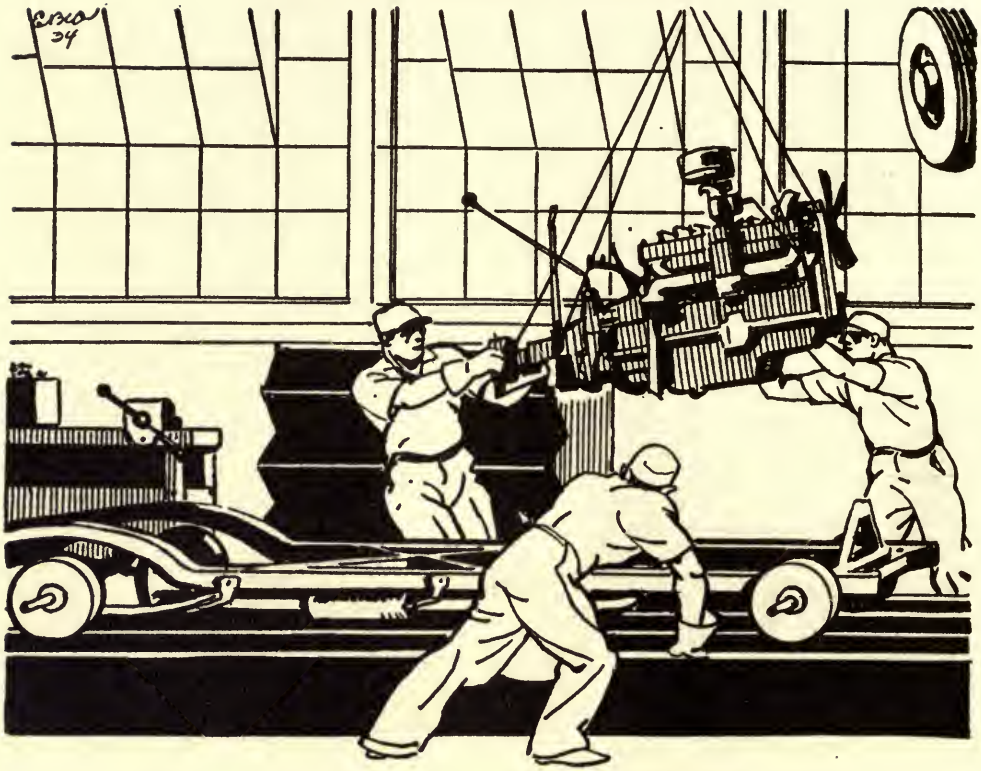


Then the heavy rear axle is lowered into place.

men bolt the front and rear springs in place. As they tighten the last bolt, the frame passes beyond them to the next group of men.

The place where each crew of men wait is sort of a station—but there are no stops! The assembly line crawls right along, waiting for no one.

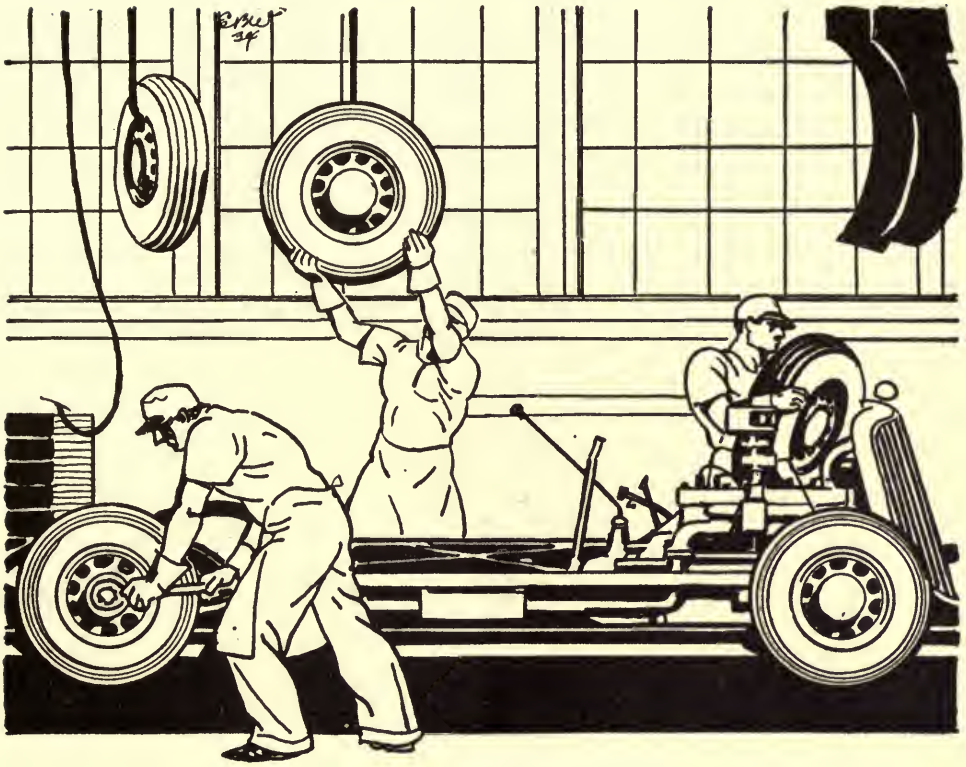
A little further down the line two men lift a front axle from the pile on the floor in back of them and quickly fasten it to the front



Here comes the engine, swinging from a crane.

of the frame. The next crew, with the help of an overhead hoist, lift up a complete rear axle and lower it into place. They tighten the bolts with a few quick turns of their wrenches, and the next chassis frame comes along.

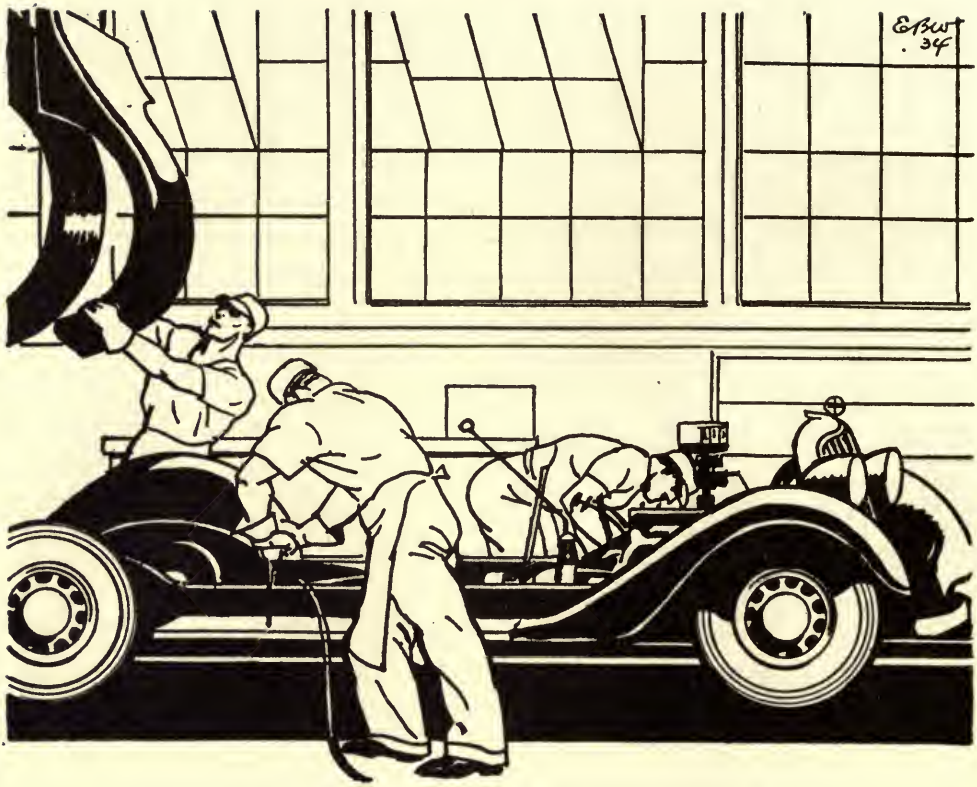
Each man knows his job perfectly. Everything runs like a clock. It is very important that it should, for a single mistake might hold up the entire half-mile line.



It takes but a minute to fasten on the wheels.

"If anything should go wrong," says Tom, "the assembly line can be stopped instantly by pushing one of these electric control buttons." He shows us one, on a steel pillar nearby. "No one but a foreman, however, is allowed to push the button."

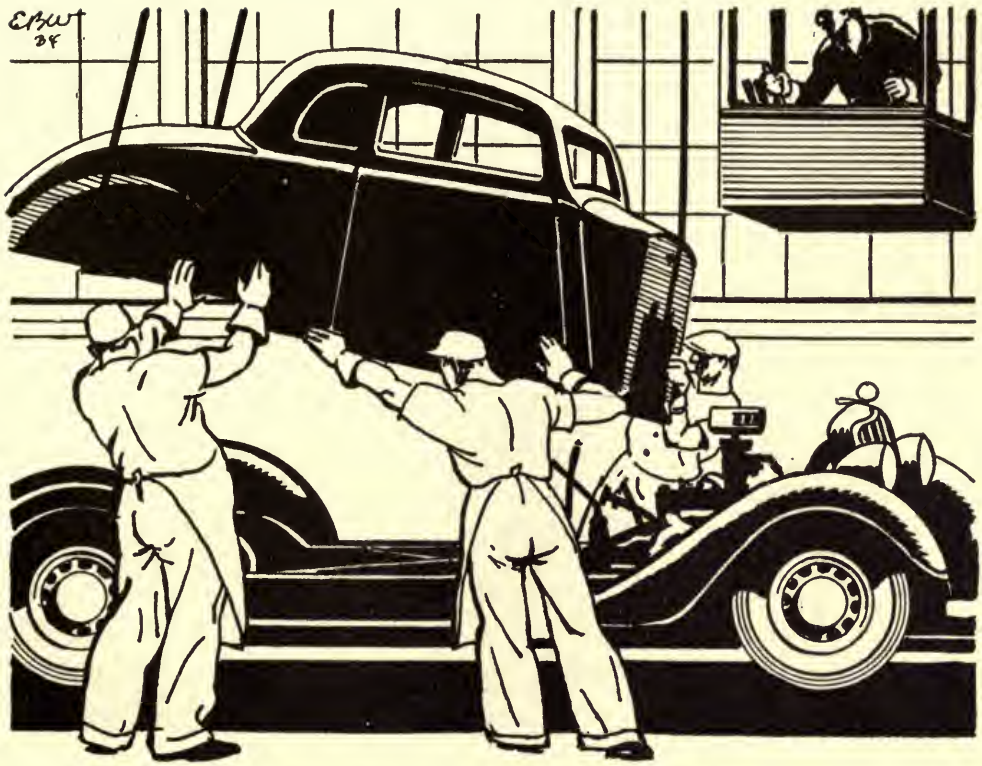
The chassis moves along a few feet further. Here its driveshaft is installed. Now it is beginning to look more like an automobile chassis, even though it is still upside-down.



The men bolt on the fenders and running boards.

"This is where they turn it over," our guide says. "Watch and see how it is done."

One of the men lowers an overhead crane so that its big tongs can be slipped under the chassis. The crane lifts its load high over the assembly line. Suddenly the operator pulls a trigger. The chassis flips right over in the air—slides off one pair of tongs and onto the other—and now it is right-side-up. It reminds us of the way a circus

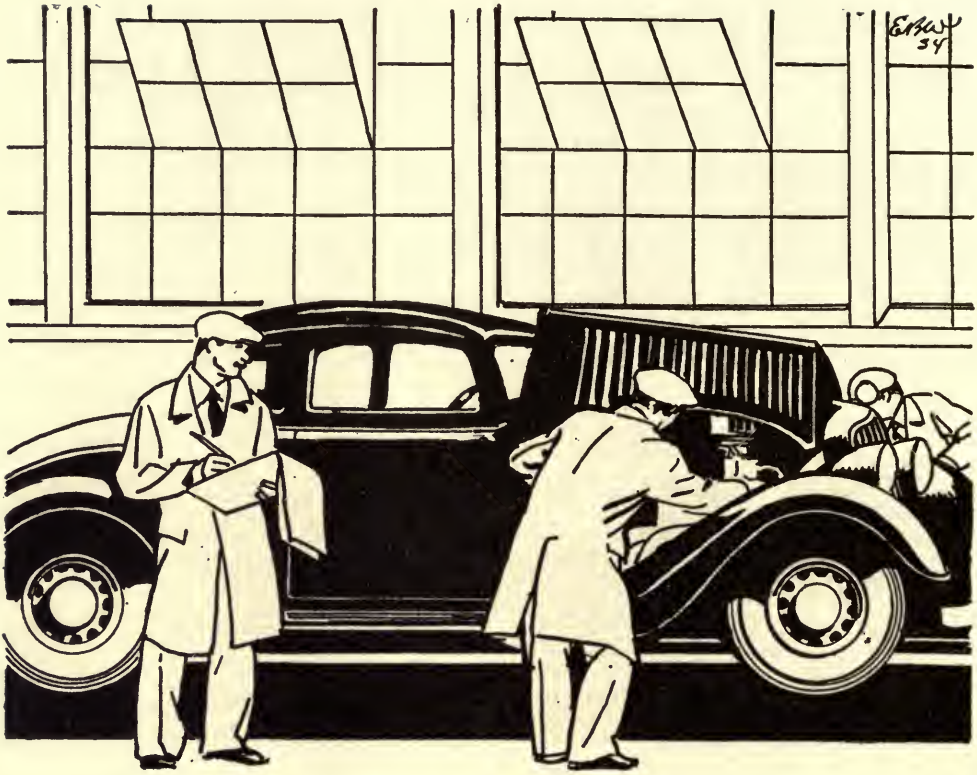


Down comes the body on to the chassis.

performer flies from one trapeze to another in mid-air! The men lower the chassis once more onto the track. It all happened so quickly that we could hardly see it!

Now the foot pedals go in. One for the clutch and one for the brakes.

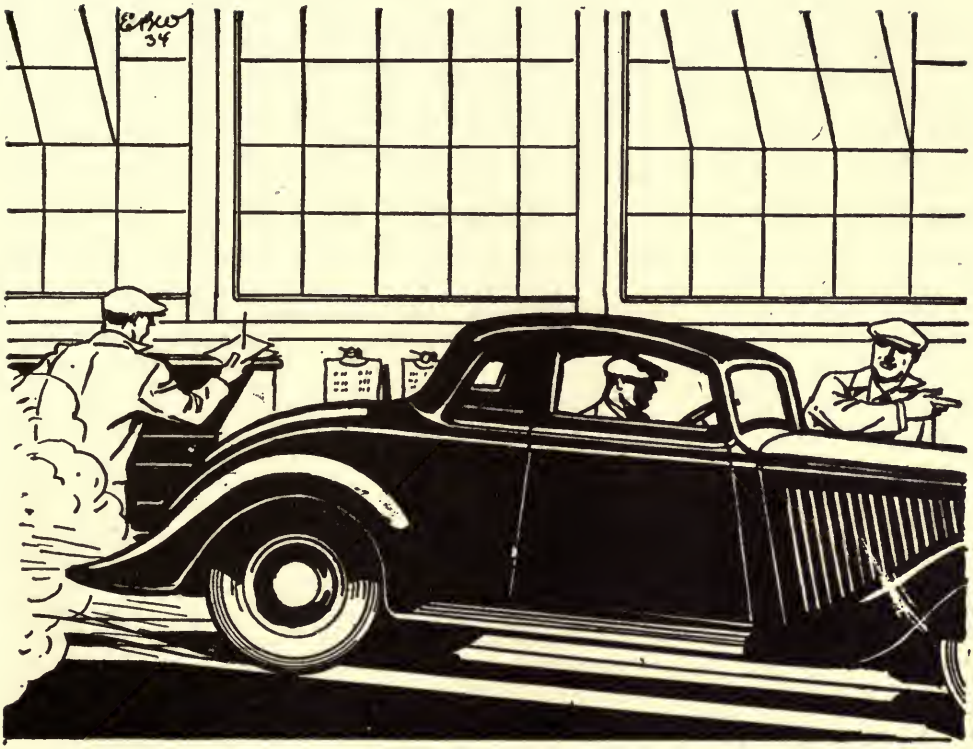
The chassis creeps along to the next crew of men, who clamp a long tiny copper tube along each side of the frame. Both tubes run



Final inspection.

the whole length of the chassis. One is the "gas" line through which gasoline will run from the gas tank to the engine. The other goes to each of the brakes and carries the brake fluid that works the brakes, for these are hydraulic brakes.

While the chassis travels on to the next station other men are busy building the gasoline tank. It takes but a few minutes in the special machine just back of the assembly line. First the machine



Finished! Fifty minutes to build a car!

presses a flat sheet of steel around a large cylinder until both ends meet. When it comes out of the machine it looks like a big stove pipe. The ends are welded on in a jiffy and the tank is ready for the men who put it in place on the rear of the chassis.

Just as the last bolt is tightened, the front of the chassis is right under a powerful hook built over the assembly line. The operator swings the hook over to a feeder conveyor that is bringing the

finished engines from the Machine Shop. As soon as the hook is fastened to the engine, it swings back over the chassis with its heavy load.

"Let 'er down! Easy there, men!" the assembly foreman shouts to his crew of workmen. The engine settles down into the chassis and the men quickly tighten the strong bolts that hold it in place. The engine itself does not rest on the chassis but is held up by rubber blocks to make it run smoothly. Because of the way it is balanced it is called a "floating power" engine.

Sometimes it seems as if the men cannot possibly finish their job before the chassis has moved beyond them to the next station. But Tom says that they always do, for they are very good workmen. "Every job is timed so that the workers can do it right without hurrying too much. Each man does the same job over and over again. That is why he learns to do it so quickly."

Now the chassis is disappearing into a short tunnel built right over the assembly line. The queer boxlike affair looks like one of the old-fashioned covered bridges one sometimes sees when driving in the country.

"This is the spraying booth," our guide explains. "The chassis is now being sprayed with black paint, just as they spray the bodies over in the Body Plant. Perhaps you noticed the men covering the engine so that the paint would not get on it."

Here it comes out of the tunnel. It is glistening black.

After going along for about ten feet in the open air, the chassis

goes into another booth, longer than the first, but built over the assembly line in the same way. This is the drying oven. It is about twenty-five feet long. The chassis takes not more than three minutes to pass through the oven. When it comes out the paint is baked dry.

Half a dozen men now pounce on the chassis with wrenches for a final tightening of all the important bolts.

"O.K." says their foreman—and the men straighten up, wrenches in hand, waiting for the next chassis which follows closely behind the one they have just tightened.

Now we have to go around a big hopper that is feeding wheels to the assembly line. The wheels roll out right into the hands of the workmen. The tires have already been put on the wheels and blown up, ready for use. It takes only a moment to put the four wheels on the axles of the chassis.

At the next station the horn and engine fan are bolted into place —then the brackets that hold up the front fenders.

On goes the chassis at its slow steady pace. Now the steering wheel and steering gear are installed.

Still the chassis moves on. It has not far to go now to get to the end of the building. See these men screwing on the hub caps. Another man lifts a heavy battery from the hook of an overhead conveyor, clamps it into place and attaches the two battery cables. The battery conveyor, like all the others, is on an endless track. The batteries keep coming toward the main assembly line. Those that

are not lifted off return to the other side of the building. Perhaps they will be taken the next time they come around.

Here is another detour to make, for a big pile of running boards and front fenders is stacked up right in our path. Each running board has a fender welded to it so that they are really a single piece. The men bolt a running board and fender to each side of the chassis, which then moves on to the radiator section.

Here come the radiators, hanging from an overhead conveyor that brings them over from the middle of the building. As soon as the radiator is bolted into place in front of the engine, the two hose connections are made to carry the water to the engine. Tom says that the chassis is now complete. It moves on for its last important part —the body.

We have already seen the bodies being brought to the Assembly Plant on long trailers and set in rows on the receiving platform. Tom tells us that as the inspector looks over each body it is pushed inside the building on rollers. Then all the bodies are arranged by color. The green bodies are set in one row together—then the blue bodies, the maroon bodies, and all other colors, each by itself. Sedans, roadsters, coaches and coupés are all separated from one another. There is a reason for this, as we shall see presently.

The bodies are carried over to the assembly line by a ten-ton electric crane that runs along a track overhead. The operator rides in a cab at the front of the crane. When the crane is directly over the rows of automobile bodies, the operator lowers a cable to which

is attached a bar with a hook at each end. See how many controls he has to work! Some of the levers make the crane move along its track. Others lower the hook, and raise it. Down goes the hoisting hook! The men below fasten the lifting bar under the body.

"O.K. . . . take it away!" they shout up to the man in the cab of the crane.

He picks up the body and carries it across the building to the assembly line. The overhead track curves around so that the crane is directly over the chassis as it moves along the assembly line. The operator pulls another lever and the body is lowered down slowly into place. As soon as it rests firmly on the chassis, the men release the hooks and the crane scuttles back across the ceiling for another body. The workmen on the assembly line tighten the bolts that fasten the body to the chassis.

Some of the chassis have red wheels. Others have green, black, or blue wheels. We ask Tom how the crane operator knows what color body to bring over, for surely he is too busy to see what color all the chassis wheels are as they come along.

"Oh, that's easy," Tom replies. "The assembly foreman uses an electric message-sender called a *teletype*. For example, when he sees that the next chassis coming down the line has green wheels, he sends a message to the man in the crane telling him to bring over a green body, or some other color body that goes well with green wheels."

Now the body is installed. The automobile moves on to have its headlights and tail-light put on.

The very last small assembly line now meets the main track near its end. Engine hoods hang from its hooks. The workmen reach up, select the correct color of hood and fit it into place.

The car is now finished. Tom was right—almost! It has been exactly fifty minutes and ten seconds since the bare frame was laid on the assembly line, way back at the other end!

An inspector now climbs into the driver's seat, starts the motor and shifts into "low." With lights turned on, the car is driven down the ramp at the end under its own power.

Before it leaves the building it is given a final inspection to see that everything is in working order. While this is being done, a crew of men is busy adding the final touches. They bolt on the front bumper and the rear bumpers—clamp the spare wheel in place—pour water into the radiator—and the foreman pastes an "O.K." sticker on the windshield.

"Many automobile dealers come direct to the factory to drive away the cars they have ordered," our guide explains. "They save time and money this way. Cars that are to be driven away are parked outside the Assembly Plant in a large *drive-away* space."

Those that are to be shipped by railroad are driven onto a platform at the end of the building and loaded into freight cars that stand on the railroad siding. Still others are carried away on "drive-away" trucks with double decks, mostly to nearby cities.

"Now you have seen how cars are assembled," says Tom. "There goes our car now, onto the platform for shipment. The Plant is

working at full capacity to-day. We are trying to catch up with orders. Before night more than 1,900 finished cars will roll off the assembly line."

We cannot help thinking how long it would have taken one of the pioneers, thirty years ago, to build even one-tenth as many cars as this Assembly Plant turns out in a single day!

"I think you are supposed to go back now to see the Chief Engineer," Tom tells us. "He wants to show you how the finished cars are put through their tests."

We thank Tom for showing us the assembly line and start back across the yard to the Engineering Laboratory.

X

"HIT THE ROAD!"

THE Chief Engineer is waiting for us in his office.

"Well, boys," he says, "you have seen how we make our cars. Now you will see how we wreck them! In a few minutes I will drive you out to the testing grounds—but first I want you to see one of our test fleets starting on its cross-country run."

On his desk are many maps, showing roads and highways in every part of the country. He introduces us to a man who is standing by the desk looking at the maps.

"This is Frank, one of our test-fleet captains. His fleet is starting right now for the West Coast. We have just been working out the route."

Frank tells us that there are five new cars in his test fleet. He drives one of them himself. There are four other men in his crew. Each man is in charge of a car.

"We will travel about 25,000 miles before we get back to Detroit," he explains, as he points out the route with his pencil. "Over all kinds of roads—mud, gravel, rough mountain passes, over the hot sands of the desert, and even through snow and sleet. We drive

very fast. Sometimes when we get good roads we go five hundred miles or more between sunrise and sundown."

That certainly is a great distance to drive in one day! Most people think that three hundred miles is a good day's drive.

"Every night before we go to bed, we write out a report and telegraph it back to the Chief Engineer so that it will be on his desk bright and early in the morning. The report tells how many miles the fleet has driven that day, how much gasoline and oil we used, and how the cars are standing the trip. This information is very useful to the engineers at the factory."

The Chief Engineer gives Frank a few final instructions.

"Are you all set now?" he asks.

"Yes, Chief," Frank replies. "We're ready to start the minute you give the word."

We all go out into the yard to see the test fleet get under way. Each man is in his own car, eager to start. The captain slides behind the wheel of the first car in the line and signals the other drivers.

"We're off, boys! Let's hit the road!"

The engines roar and the fleet cars speed out through the gateway. They're off on their cross-country trip!

The Chief Engineer tells us that there are two other fleets like this one on the road right now. One is crossing the high mountains of western Pennsylvania, heading for home. Another is speeding north across the plains of Texas. By looking at the reports each morning, the Chief Engineer knows where each fleet is.

There are several other kinds of test cars besides the cross-country fleets. Some of the new cars are made into taxis. They are shipped to big cities and put into service to see how they "stand up" under the extra hard use that taxis get.

Plowing through the sand in the desert test.

Other cars are taken off the assembly line and given to a special crew of drivers for traffic tests. These men drive them thousands of miles without even leaving the city of Detroit! Day after day, and all night long, they drive around the city streets in the traffic, stop-

ping only for gasoline and oil, and to change drivers. The men work in three shifts. Each man drives for eight hours without stopping and then turns his car over to another driver. The car itself never rests.

After each car has been about ten thousand miles in city traffic, it is brought back to the factory and "torn down." Trained mechanics take it apart, piece by piece, for the engineers to look at. They want to know how every part is doing its job. If some parts are wearing out too fast, they must be made so that they will last longer.

"This is a busy morning out at the factory testing grounds," the Chief Engineer says. "If we start now I think we will get there in time to see what is going on."

It is just a few minutes' drive from the factory out to the edge of the city where the engineers put the cars through special tests. This is going to be exciting! Already we can see a group of men around a car that is standing in the field. We get out of our car and walk over to see what is going to happen.

"Well, we got here just in time to see the collision test," the Chief Engineer says. "Let us hurry over."

As we get closer we see that workmen have built a long wooden track. At each end of the track there is a new factory car. Both cars are the very latest models, just as they have come off the assembly line. A mechanic is in each car, warming up the engine. The tracks are grooved so that the wheels of the cars will follow the track without being steered.

Suddenly one of the engineers gives a signal. The mechanics shift into gear and the two cars start moving down the track toward each other. What a collision this will be! As the cars gather speed, the mechanic in each car opens the throttle wide and jumps out.

On come the cars down the track, without a driver, straight for each other. Faster and faster. Fifty . . . fifty-five miles an hour. Finally, at sixty miles an hour they crash head-on! What a noise!

As soon as the smoke clears away we go over with the engineers to look at the cars. Both radiators are smashed, of course, and one of the engines has been pushed right back into the driver's seat. It is a good thing the mechanics jumped out before the crash!

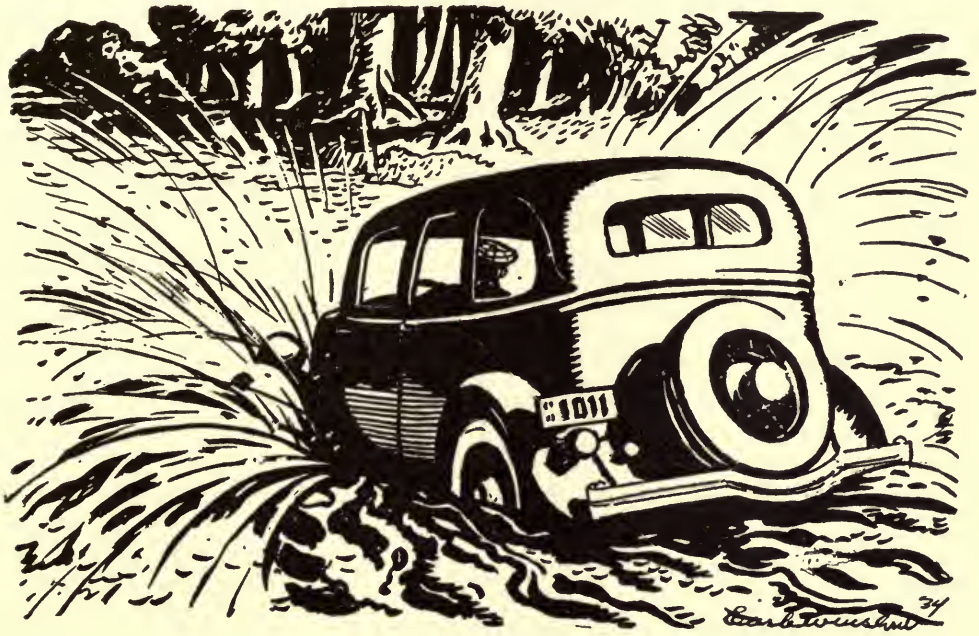
"There isn't much left of those two cars, is there!" says the Chief Engineer. "But my men will poke around in the wreckage. Every collision like this tells a story to them. It shows them what parts are strongest, and what parts can be made even stronger. We must make the cars as strong as we can so that people will be safer if they should happen to have a real collision."

He leads us away from the wrecked cars. Later, he says, his men will tell him what they found out by studying what was left of the cars.

"Over here is the bath-tub," he tells us.

A bath-tub! For washing cars? Not at all! This is something quite different, he explains. It is a short road that dips down suddenly into a hollow filled with water about two feet deep. Now we shall see what happens, for here comes a car speeding along.

Splash! Right into the deep pool of water it goes! Sheets of water splash up around the front of the car and right over the top. The driver had closed his windows before making this test. He was very wise. If he had not, he would have had a real shower bath.



Into the pool of water it goes!

"That car looked almost like a submarine, didn't it!" exclaims the Chief Engineer. "You see, we want to be sure that our cars will not stall even if they are caught out in a sudden downpour of rain. The brakes must work perfectly, too, even when the car runs through

deep puddles. Any car that can come through the bath-tub test and still run is just about water-proof, don't you think?"

Near the bath-tub is a stretch of rough road called the "Belgian Road." The Chief Engineer says that it has been made so that it is like the roads in some parts of Belgium—the roads that were torn to pieces during the war by heavy trucks carrying guns and supplies to the soldiers. It is paved with big cobblestones, with deep holes and high bumps everywhere.

We see one of the cars driven over the Belgian Road. Crash! The front wheels hit one of the big cobblestones. Bang! The rear wheels sink into a hole and bounce out again. Still the test car goes on, bouncing and jerking over the rough road.

"We sometimes call this the spring-buster," one of the men says. "But it doesn't break many springs on these new cars. It taught us how to make them so strong that they do not break."

There are still more exciting and interesting tests to see.

Suddenly a driver speeds down a smooth cement road not far from where we are standing. We are told that a small dynamite cap has been put on one of the front wheels so that it will explode when the car goes sixty miles an hour. Bang! There it goes—a blow-out! The car jerks to one side but it stays on the road. By seeing what a car does when it has a tire blowout, the engineers work out a way to make it easier to keep the car under control. This means that it is safer to drive.

Nearby is another factory car, plowing through sand and gravel

up to its hubs. The wheels spin, throwing up a thick spray of sand behind them. But the car plows right on through.

Another car is bucking against a thick post that has been driven into the ground. The car pushes against the concrete post in low gear with the throttle wide open, but the post does not even budge. The spinning rear tires get so hot that they smoke. We can smell the rubber burning. But still the great gears grind on without breaking down.

Over at the other end of the testing grounds is a large speedway, a real cement race track with sides banked steeply so that the cars do not have to slow down to take the curves. There are three test cars on the track now, racing round and round at top speed. Engineers with stop-watches stand at the finish line, timing the cars on each lap. One of the men speaks to the Chief Engineer as we come over.

"Dick did that last lap around the track at ninety-three miles an hour, Chief. What a speed demon!"

"He will do better than that with the new gears we have just made," the Chief replies. "To-morrow I think they will be ready for a try-out. See if he can do a hundred miles an hour with them."

We watch the cars racing around the speedway. They roar past us with their "cut-outs" wide open.

"If you have seen enough of this, let us go over here and see the most exciting test of all," the Chief Engineer suggests.

Over at the edge of the testing grounds a mechanic is getting into a test car. Now see what happens! He drives it over to the end of

the testing grounds—to the brow of a steep hill that drops down almost straight for more than a hundred feet. When the car is almost at the very edge he shuts off his motor and gets out. One of the men shouts, "Come on, everybody! Give us a hand!"

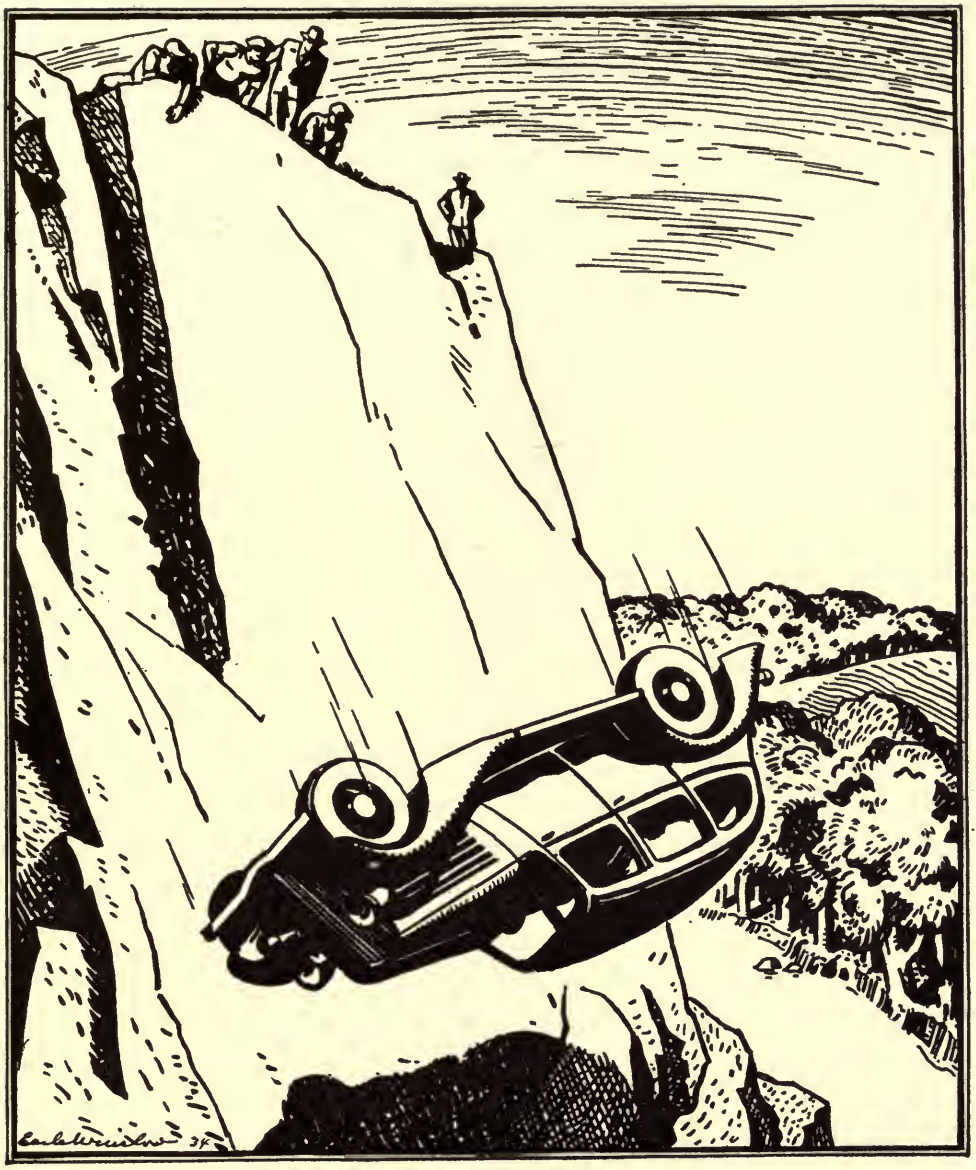
All together they lift one side of the car and with a final push they topple it right over the edge of the hill-top. Crash! Bang! Over and over it rolls, bouncing end-over-end and falling faster every time it hits the side of the hill.

First the front wheels crash into the bank—then the car turns a complete somersault, and the rear wheels dig into the hillside, sending loose gravel and earth in all directions. One, two, three, four, five, six times the car hits the ground on its way down. Finally, with a loud crash it hits the very bottom and lands upside-down.

The engineers rush down to look it over. We follow them. Surely there cannot be very much left of the car! We wonder how it will be taken to the junk yard.

The men lift the car and tip it far enough so that it falls over onto its wheels again—right-side-up. And what a surprise! Although the fenders have been bent and twisted all out of shape and several of the windows have been cracked by flying stones, the automobile seems to be damaged scarcely at all!

"That's how strong these steel bodies are!" one of the engineers says proudly. He opens each of the doors, one at a time. Not even the doors have jammed shut. And now the most surprising thing of all happens. The mechanic gets behind the wheel, presses the starter,



Crash! Bang! Over the edge of the hill-top!

and drives the car away under its own power! He didn't even lift the hood to see whether the engine was all right!

The Chief Engineer smiles. "That is just one of the tests we put the cars through to find out how good they really are," he says. "We know that if we can make our cars strong enough to turn somersaults down a steep hill like this, it would take a pretty bad smash-up to damage them on the road."

He tells us more about the tests as we walk over to his car.

"Now you see why we think our cars are the best in the world, boys. After all, testing is one of the most important jobs in making automobiles."

On the way back to the factory we thank the Chief Engineer for letting us go through the Plant and see so many of the tests. He says he hopes we will come back again some day, and he tells us about some of the ideas that his men are working on now. Some of them are very secret, and will be used in next year's cars. Others may not be ready for five or ten years.

Automobile engineers must always plan very far ahead.

XI

"AMERICA ON WHEELS"

MORE than one hundred and twenty million people live in the United States. There are millions of automobiles, too. In fact, there are so many that if every person who owns one should invite four other people to ride with him, every man, woman and child in the United States could go for an automobile ride at the same time.

Let us hope that such a thing never happens. Think of the traffic jams there would be on every highway!

Millions of cars! Yet each year several million of them become worn out and finally end in the junk yard. To take their place, millions of new cars roll off the assembly line of America's great automobile factories.

These new models are always better than the ones that came before. We have seen how hard the engineers work to make them better.

What do you think automobiles will be like ten years from now? Even five years from now? Road engineers seem to think that cars of the future will be faster, more powerful, and even more streamlined, for they are planning wide super-highways on which it will

be possible to drive very fast. Already, streamlined cars have made ordinary cars seem very old-fashioned.

Things happen so quickly in the automobile industry that we cannot even guess what some of the new ideas will be.

One automobile company already builds a car that has no gear-shift lever. The driver has only to start the engine and steer the car. It shifts for itself!

Do you remember when most cars had six-cylinder engines, and there were many with just four-cylinder engines? Very few people could own an eight-cylinder car in those days. But to-day more than half the cars that are made have eight-cylinder engines. A few have twelve and even sixteen cylinders.

Do you think there will ever be a thirty-two cylinder car? Probably not, but some engineers have been trying for a long time to see whether it would be a good idea to build a car with a Diesel engine. A Diesel engine has no spark plugs. It runs on oil instead of gasoline. Many large boats use Diesel engines, but engineers have not yet decided whether it is possible to design a small Diesel engine for motor cars.

Not so long ago, "knee-type" wheels were used on automobiles for the first time. Instead of having a front axle, each front wheel is attached by springs of its own so that it will go over bumps without jolting the people in the car. To-day almost every make of car has some kind of "knee-type" wheels.

The engineers in one factory designed a car with a "front-wheel"

drive. The engine was geared to the front wheels, instead of having a driveshaft to turn the rear wheels. Some engineers think that the car of the future may have the engine in the rear instead of at the front!

125 miles an hour on three wheels!

Another make of car is "air-cooled." It has no radiator for water to cool the engine, but depends upon air rushing through, and special fans, to keep the engine from getting too hot.

Another car has "twin ignition," with two spark plugs for each cylinder. The engineers say that this arrangement makes a hotter spark to explode the gasoline.

Many cars of to-day have no starter button. Just press the accelerator pedal and the engine starts! Others have automatic clutches. The driver may shift gears without even touching the clutch pedal.

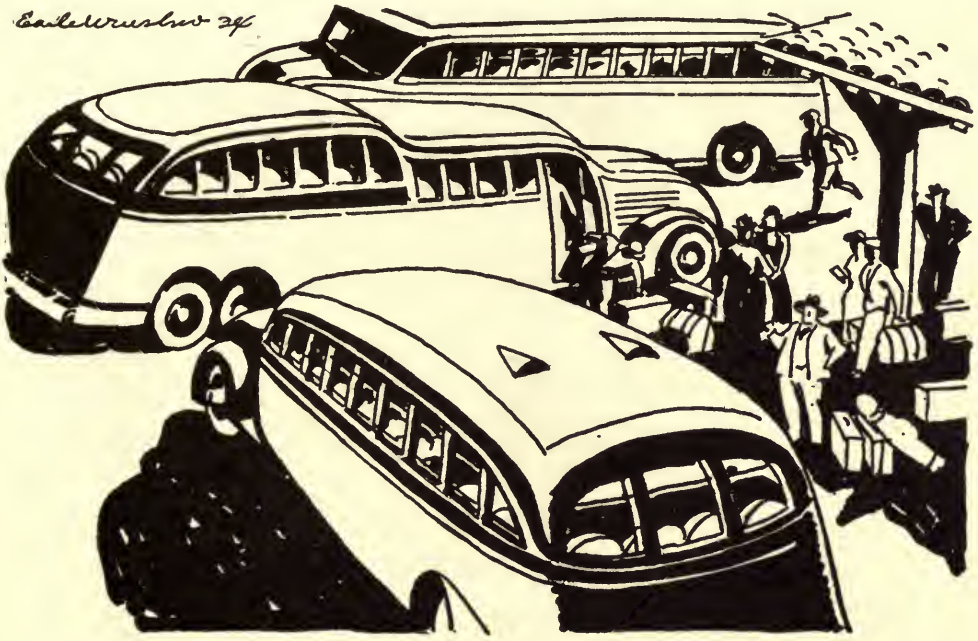
One engineer designed a car with three wheels—two in front and one at the rear that steers the car very much as a rudder steers a ship. This car is streamlined so that it is almost the shape of a bullet. In recent tests it went 125 miles an hour!

The automobile serves the farmer in many ways.

Some ideas, such as all-steel bodies and shatterproof glass, are for safety. Other ideas have been used because they make the car easier to drive, or more comfortable to ride in.

The car of to-day is quite different from the old gas buggy with

its whip socket on the dash! What would one of the early pioneers have thought if he could have speeded quietly along at 80 miles an hour, sitting in a seat as comfortable as an easy chair, protected



Great automobile busses span the country.

from drafts and wind by windows that open in a special way, and listening to music played by a radio right in the car!

And how surprised he would have been if he could have looked ahead thirty years to see our city streets and country highways teeming with millions of automobiles, busses and trucks—"America on wheels!"

WIDE ROAD AHEAD!

The motor car, you will agree, has done more than anything else to change our way of living. Because it takes only a few minutes to drive many miles, the automobile has really brought our farms close to our cities, and our cities closer together.

The farmer who used to take his crops to market in the nearest town by wagon now speeds along a cement highway in his truck to cities fifty and a hundred miles away, where he can get higher prices for the things he grows on his farm.

Swift inter-state busses span the United States, running on schedules just like express trains from New York to the West Coast, and from Chicago to the South.

In our city streets, delivery cars and trucks speed from stores to customers' houses with groceries, rugs, clothes and all kinds of packages.

Five-ton trucks and ten-ton trucks with trailers rumble through the streets with their loads of steel, lumber and coal. Some of them even mix cement in giant mixing tanks as they carry it to some skyscraper that is being built. Big tank trucks carry fresh milk from the country farms to the city. Others have derricks built right on their chassis for lifting heavy loads.

If we happen to be on foot and wish to get somewhere quickly, we have only to raise our finger and a taxi scoots to the curb and whisks us to the other side of the city for a few cents.

Some of our big cities have fleets of police "radio" cars that cruise about the streets. When a message from "Headquarters" flashes

over their radios, they rush to the spot where there is trouble. Perhaps the radio message tells of a "hold-up" that is taking place. The radio cars get there so quickly that the robbers do not have a chance to get away before they are caught.

The automobile fire engine.

There are other ways in which automobiles save lives and property. How thrilling it is to see a fire engine and a six-wheeled hook-and-ladder roaring through traffic with their sirens shrieking—or an ambulance flashing by with "right of way" over all other cars!

WIDE ROAD AHEAD!

If you live or drive in the country you have seen the automobile's "country cousin"—the tractor. The farmer uses his tractor to plow his fields, gather his crops, cut fire-wood, and do all sorts of heavy work on the farm.

Farmers, doctors, milkmen, builders, firemen, salesmen, storekeepers—every business depends upon the automobile. Some companies even have fleets of cars and trucks that are on the road every day in the year.

It is hard to think how the world could get along to-day without the automobile!

Grateful acknowledgment is made to the officials, engineers, foremen and workmen of the Chrysler Corporation who assisted the author in gathering most of the material used in this book from first-hand observation in the Plymouth, De Soto, Dodge and Chrysler plants and engineering laboratories, and for their kindness in verifying the accuracy of the facts as they have been presented.

The Illustrator—

EARLE WINSLOW

In these books of Mr. Lent's the illustrator makes an important contribution. Mr. Winslow, a well-known and versatile artist, uses the greatest care and skill in explaining in pictures, the interesting story of "how things work." Just as in the case of *Clear Track Ahead!* (trains) and *Full Steam Ahead!* (steamships), Mr. Lent's earlier books,—he has done a great deal of research for this story of the automobile. Many of the drawings were made at a Detroit factory and his illustrations are accurate and entertaining with an unusual touch of humor.

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